Review of federal policy to mitigate the impact of microplastics: A comparative study of European Commission's Plastic Directive Vs Canada-wide Strategy on Zero Plastic Waste by CCME

by
Shivani Chhabra

Supervised by
Prof. Mark S. Winfield

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FOREWORD

This major paper is my final submission towards the completion of the Masters in Environmental Studies (MES) program at York University, Canada. My Plan of Study was primarily focused on Water Quality and Sustainability. The plan of study was developed with the help of coursework and the IDSs (Independent Directed Study) that I took during the two years of my program. I completed some onsite and online course as a part of IDS from Walkerton training center to understand the laws and regulation related to water quality systems in the province of Ontario. The major paper is linked to the area of concentration that helps to investigate issues about water quality in Canada.

Plastic is most common pollutant found in the water bodies that is responsible for the deteriorating quality of water and decreasing marine wildlife. It is one of the important non-point source which are challenging to manage because the point of origin is unknown. The main focus of the paper is to look into the issues related to plastic waste disposal and an effort is made to compare the waste management strategies adopted by different jurisdictions nationally or internationally.

It fulfils the learning objective 3.3, "To gain useful knowledge about plastic waste in aquatic ecosystems including both marine and freshwater ecosystems. This includes obtaining a better understanding of micro-plastic pollution, its definition, possible sources and treatment" set in the plan of study for component 3, "Water pollution and policy."

This major paper further elaborates mitigation strategies related to water quality, considering the goals of sustainability set by the United Nations. One of the components of my Plan of Study was "To understand the fundamental nature of sustainable development and determine the trends in water quality management, while the other was "To gain useful knowledge about the relationship between water quality and sustainability" set in component 1. This research help me exploring and gaining more knowledge about the Sustainable Development Goals that are important for maintaining the quality of water.

An objective of this study is to examine the possible policy options available within Canada to mitigate the impact of microplastic on the aquatic environment which fulfilled the learning objective 2.2, "To be familiar with the Canadian laws and policies to protect water bodies in Canada. To understand the process of policy implementation in Canada" set for component 2 in the plan of study. To understand, this I have attempted to explore the need for a broader ban on single-use plastics as a strategy to prevent the pollution of aquatic ecosystems and potential mechanisms for the implementation of such a ban at the federal level.

To investigate further, I attempted to do a comparative evaluation of the European Union Plastic Directive that has successfully adopted a single-use plastic ban this year and is moving ahead in their attempt to eliminate microplastic pollution. In addition, this paper contributes to further understanding and experience to the educational goals of completing my MES program.

ABSTRACT

Water is a renewable resource and is a quintessential need for organisms to survive on earth but only when used sustainably. Water plays an indispensable part in achieving the goals of sustainable development that includes health and social needs and economic growth. Maintaining the quality of water is an essential step towards achieving the goals set for sustainable development. However, some anthropogenic activities are responsible for adding impurities to water through improper industrial and domestic waste disposal. This could be the solid waste or toxins released from these solid wastes. Plastic is a form of solid waste that has become the contributor to the deteriorating quality of water around the world. It has been estimated that nearly 8 million tonnes of plastic end up into the oceans each year (Boucher et al. 2017). It takes approximately 1000 years for a plastic material to decompose completely from its disposal site (The Green Space, 2010). The growing use and inappropriate disposal of plastic products in our everyday life continue to reduce water quality. Marine animals and dead birds containing tiny plastic pieces discovered in their guts are nowadays a common site.

More than the plastics scientists and environmentalist around the world are becoming concerned about microplastics. Tons of plastic waste end up into the oceans from dumping sites intentionally or unintentionally, and this plastic waste further breaks down into smaller pieces named microplastics with the help of sun, chemicals, and other microbial activities. If we continue to suffocate our waters like this, the use of plastic cannot be considered sustainable anymore.

Although Canada has already taken up the first steps towards banning microbeads in July 2018, there is still a lot that needs to be done in microplastics. Strengthening the Canadian Environmental Protection Act, 1999 could be one of the solutions, where the primary purpose of CEPA is to contribute towards sustainable development and achieving the protection of the environment from toxic substances explicitly mentioned in one of its guiding principles. This paper has attempted to highlight the progress made by the EU to manage their (micro)plastic waste with enhanced recycling methodology along with innovative designs for plastic production. The Canadian government should take an example of such models to strengthen further its efforts towards mitigating the impacts of microplastic pollution and regulating them.

Keywords*: Water quality, sustainable development, plastic debris, microplastics, aquatic ecosystem, Canadian Environmental Protection Act, circular economy and waste management*

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LIST OF ABBREVIATIONS

1. CCME- Canada Council of Minister of Environment
2. CEPA- Canadian Environmental Protection Act
3. EAA- Environmental Assessment Act
4. EBR- Environmental Bill of Rights
5. EU- European Union
6. GESAMP- Group of Experts on the Scientific Aspects of Marine Environmental Protection
7. HCH- Hexa-Chlorinated Hexane
8. IJC- International Joint Commission
9. IMO- International Maritime Organization
10. NIAS- Non-Intentionally Added Substances
11. PCB-Poly-Chlorinated Biphenyls
12. POPs- Persistent Organic Pollutants
13. SDGs- Sustainability Development Goals
14. REACH-Regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals
15. UNEP- United Nations Environment Program
16. UNDESA-United Nations Development of Economic and Social Affairs
17. UNDP- United Nations Development Program
18. UNESCO- United Nations Educational, Scientific, and Cultural Organization
19. WWF- World Wide Fund

CHAPTER 1: INTRODUCTION AND BACKGROUND

Water is a renewable resource and is an essential need for the organisms to survive on earth but only when used sustainably. It covers about 71% of the earth's surface out of which only 2.5% is available as freshwater in rivers, lakes while the rest is locked in frozen glaciers or as saltwater in the oceans (Khyade et al. 2016). Canada is the land of Great Lakes and considered to be a freshwater-rich country with almost 7% of the world's reliable flow of freshwater and many of the world's largest rivers (Natural Resources Canada, 2017). The resources and the energy industries mainly use the water trapped in the Great Lakes (Natural Resources Canada, 2017).

Water plays an integral part in achieving the goals of sustainable development that includes health and social needs and economic growth. It is significant for manufacturing, recreation, and industrial activities. Shortages of water can affect farming practices since it is a raw material for food production and can impact the industrial development of a country. Similarly, maintaining water quality is a crucial step. We have water in nature in its purest form from lakes, rivers, and rainfall. However, anthropogenic activities are responsible for adding impurities to water through industrial and domestic wastes. This accumulation of wastes into water is the major contributor to the deteriorating quality of water in the past few decades. It may endanger the freshwater and other aquatic ecosystems.

Lack of safe access to clean water can lead to health problems in humans. The degradation of the quality of water can be blamed on rapid growth and urbanization. With rapid growth and industrialization, new tools have been designed to make our lives easier;

plastic is one. With unauthorized dumping plastic has become the contributor to deteriorating the quality of water around the world. It is abundant in the environment. The potential release of plastic waste is calculated between 4.8 Mtons/year to 12.7 Mtons/year with an average value of range between 8.0 Mtons/year (Boucher et al., 2017). Since the time of its first production in 1907, plastic has become a significant contributor harming the marine and freshwater ecosystems (Xanthos et al. 2017). We are struggling with the ever-increasing waste in our surroundings be it is a terrestrial or aquatic ecosystem. If we continue to suffocate our waters with plastic debris, the use of plastic cannot be considered sustainable. The various shoreline clean-up activities have reported that more than 80% of litter in the Great Lakes stems from the anthropogenic activities (Driedger et al. 2015b).

i. WATER QUALITY AND SUSTAINABILITY

The water that we use mainly determines the quality of our lives. However, the quality of water is deteriorating across the globe daily. Water quality and sustainability are closely related. Sustainable development concept was introduced in 1987 by the Brundtland Commission, which stated {A/42/427}, (Brundtland Report, 1987).

> "development that seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future"

Hence, the development that does not promote depletion or deteriorating the quality of natural resources and keeping them safe for future use is called sustainable development. Water is vital to sustainable development and is crucial to socio-economic development (UNDESA, 2015). Maintaining the quality of water is an essential step towards achieving the goals of

sustainable development. According to the Statement submitted by Human Rights Advocates at the United Nations General Assembly {A/HRC/40/NGO/235}, (United Nations, 2019).

> "Water is at the core of sustainable development and is not only critical for food production, but also for human survival, socio-economic development, energy and healthy ecosystems."

Although sustainable use of water is an essential component of long-term water planning, there is still unsustainable use of water in the globe that threatens both human and environmental survival (Gleick, 1996). Water quality largely depends upon the land use patterns as the disposal of solid wastes into the rivers and lakes that may have a significant impact on the health of the ecosystem and the downstream communities (UNDP, 2016). At the International level, United Nations General Assembly has adopted specific sustainable goals for the waste management under resolution {A/RES/70/1} "Transforming Our World: The 2030 Agenda for Sustainable Development" on 25 September 2015 (WHO, 2016). The United Nation's 2030 Agenda for sustainability has set 17 Sustainable Development Goals (SDGs) out of which SDG 14 talks about preservation and sustainable use of water and also encourages immediate action to maintain the quality of water. SDG 14 seeks to a considerable reduction in the marine debris by 2025 (WHO, 2016). Marine litter was raised as an issue of concern at the United Nations Conference on Sustainable Development in 2012 (Rio+20) with specific reference to marine litter in the outcome document {paragraph 163, A/ RES/66/288}, (GESAMP, 2015).

"The future we want': 163. **We note with concern that the health of oceans and marine biodiversity are negatively affected by marine pollution, including marine debris, especially plastic, persistent organic pollutants, heavy metals and nitrogen-based compounds, from a number of marine and land-based sources, including shipping and land run-off**. We commit to take action to reduce the incidence and impacts of such pollution on marine ecosystems, including through the effective implementation of relevant conventions adopted in the framework of the International Maritime Organization (IMO), and **the follow-up of the relevant initiatives such as the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, as well as the adoption of coordinated strategies to this end**. We further commit to take action to, by 2025, based on collected scientific data, achieve significant reductions in marine debris to prevent harm to the coastal and marine environment."

The para 163 of the document identifies plastic debris as the major deteriorating factor for the quality of water either through land-based sources or aquatic sources such as spilling of pellets while shipping. As a result, the first UN Environment Assembly, which took place at Nairobi in June 2014, raised the problem of marine litter and microplastics (GESAMP, 2015). There was a mention of phasing out primary microplastics, which includes not just intentionally added microbeads but also industrial abrasives (UNEP, 2016a). Each year tonnes of plastic waste ends up into the oceans either from the landfills, intentionally or unintentionally, or from some other land and water-based activities. This plastic waste further breaks down into smaller pieces with the help of sun, chemicals and other microbial activities. More than plastics it is the smaller piece of plastics called "microplastics" that have become a particular concern in the marine as well as the freshwater ecosystems. Though acknowledged as a significant pollutant worldwide, not much has been achieved as a solution to this issue.

ii. FACTORS AFFECTING WATER QUALITY IN CANADA

There are mainly two primary sources of water pollution; point source and non-point source. The point sources discharge directly into water bodies from various sources like sewage treatment plants, drainage pipes or waste from industries. The non-point source, also known as diffuse pollution, contaminates water bodies from different land-use activities, mainly during rainfall or storms and farm spills. It has been reported that non-point source is a major problem to control as the regulations as the source of the pollution is unknown and is from various activities. Many factors that contribute to the deteriorating quality of water and plastic is one of them.

Inappropriate plastic waste disposal plays an indispensable role in increased water pollution. Pollution from the plastic debris is a global problem causing adverse impacts on marine and freshwater aquatic environments (S. Pettipas et al. 2016). Concerning marine environments, approximately 80% of plastic litter entering the oceans comes from land-based sources, while the rest 20% comes from ocean-based activities, such as fishing and shipping (Chow, 2015). With the advancement of technology, the growing use of plastics is substantially affecting water quality. The improper disposal of plastic litter such as coffee cups, straws, plastic bottles and plastic bags (figure 1) finds its way to the drainage system during bad weather days like rains or snowstorms. From here this discarded plastic litter enters water pipes to finally ending up into water bodies like rivers, lakes and oceans.

It takes years for this litter to break down into microplastics while contaminating the water quality with toxic chemicals (UNEP, 2018b). Hence, there is a possibility of contamination of water from the chemicals that are absorbed from the plastic-based debris.

The harmful chemicals can leach into the environment either as a primary product absorbed directly from the environment or as a by-product during manufacturing.

Figure 1: Plastic litter around a neighborhood in Vaughan

The toxic chemicals like vinyl chloride and styrene present in the (micro)plastics are sometimes carcinogenic (Galo et al. 2018). The phytoplankton can die due to the accumulation of these toxins in their bodies by ingesting them. Recent studies have suggested that approximately 6300 Mt of plastic waste has been generated as of 2015 out of which just 9% of the plastic has been recycled, 12% has been incinerated and 79% has been landfilled (Geyer et al. 2017). Microplastics have been reported in the Shellfish (some kinds of which are common in freshwater) and in some processed food and beverages such as sugar, beer and salt (Wright et al. 2017). However, the impacts of microplastics in food destined for human consumption are unknown (Wagner et al. 2014). Microplastics have been increasingly detected and reported in both marine and freshwater ecosystems. There is no scientific data on the amount of plastic in the ocean and the freshwater system collected so far.

CHAPTER 2: METHODOLOGY

i. RESEARCH QUESTION

a. What are the plans of the federal government to keep microplastics out of Canadian Waters and mitigate the impact of microplastics on Canadian marine and freshwater ecosystems?
b. Can bringing a ban to use of single-use plastic will act as a solution to the microplastic problem? If yes, how?
c. What is missing from the zero waste strategies in Canada as compared to the EU Plastics directive?

ii. OVERVIEW

Maintaining the health of our aquatic ecosystems is the main priority globally to achieve the goals of sustainable development (sustainabledevelopment.un.org). Currently, the water quality of marine ecosystems is continuously deteriorating. The main contributor to this being the inappropriate disposal of plastic waste. More than plastic, microplastics have become the most significant area of concern as they are non-biodegradable. The current study is based on a review of federal policy by implementing the blended qualitative research strategy that involves a review of literature as well as interviews with subject matter experts. This chapter will give an insight into the methodology adopted for the following research study. The study utilized the literature review approach extensively to understand the research problem better and identify gaps in the existing literature along with few insights from the expert interview. The methodology chapter covers a selection of topics, the research strategy, plan and the limitations of the tools used in the research study. The section eventually culminates with a brief analysis and discussion of the data collection, methods and strategies, and obstacles encountered during the research study. A comprehensive literature review was carried out

for this research after that the collected data were analyzed. Conclusions were drawn from the information gathered with the help of a literature review and expert interviews.

This paper is classified into eight chapters, where chapter one focuses on the introduction and background of the water quality and sustainability and tries to explain how the two are interrelated. Chapter three includes a literature review, which focuses mainly on issues such as microplastic definition, source, type and effects. Chapter four examines the function of CEPA to regulate microplastic pollution in the aquatic ecosystem, to understand the role of the Canadian Environmental Protection Act of 1999 (CEPA). This chapter also includes a discussion about the guiding principles and possibilities to add microplastics to the list of toxic substances Schedule 1 under CEPA. The federal and provincial policy initiatives were explored with the help of comparison between them to bring a complete ban to single-use plastic. Chapter five discusses the need for the microplastic pollution control regulation, primarily in the context of the EU Commission's Plastic Directive. The intention is to explore tools and strategies available in other jurisdictions that are missing in the Canadian zero plastic strategy and fill that gap to control microplastic pollution. The concluding chapters focus on the recommendations and discussions that will assist in adopting a nationwide ban on single-use plastic and hence moving towards achieving the goal of sustainable development.

To explore the issue of microplastic, we must approach the problem at the source around the plastic waste is generated. Hence, the main focus was on getting inspired from the other jurisdictions that have successful policy models related to plastic waste management running nationally and internationally. Initially, the study focused on the assessment of CEPA 1999, which deals with toxic substances list under Schedule 1, but later also explored other

alternatives owing to the absence of information microplastics. An attempt was made to make a jurisdictional comparison between the European Union Commission's Plastic Directive with the Canadian Council of Ministers of the Environment's Zero Plastic Waste Action Plan released in 2014. Other appropriate policy models were also evaluated within Canada on the Government of Canada websites such as Green Procurement and the OCEAN PLASTICS CHARTER.

iii. LITERATURE REVIEW

The following research applied the primary method of qualitative research analysis to study the implications of the microplastic in the environment and humans. The methodology involved the assembly of the information collected. A literature review was accomplished, focusing on the problem statement that examined the research and theory already exists. Information was collected primarily from previously accessible data, such as websites, published papers, newspapers, academic books and newspaper articles. The effects of microplastics on the marine environment were well explained in the earlier studies; however, much information on freshwater ecosystems was challenging to discover.

An extensive study carried out from the peer-reviewed papers and the baseline information linked to the subject was gathered. A "Snowball sampling" method was used to search for the literature with the help of keywords. Literature like Brennholt et al. 2017a & Anderson et al. 2016 were reviewed to understand the successful models for waste management policies in Europe and the impact of microplastics on the aquatic ecosystems. The main aim of the literature review is to collect data on the definition, sources and kinds of microplastics along with their physical and chemical effects on aquatic ecosystems (including marine and

freshwater habitats) and humans. The review was done to understand their distinction from microbeads and to understand why is it necessary to bring a ban to single-use plastic to fulfil the goals of sustainable development.

iv. COMPARATIVE ANALYSIS OF EU PLASTIC DIRECTIVE WITH CANADIAN ZERO PLASTIC STRATEGY

This paper tries to conduct a comparative jurisdictional assessment of the EU Plastic Directive (2019) with the CCME's Zero Clastic Strategy. Also studied was a background document entitled "Microplastic Pollution, Policy Context" (2018) to learn about the regulatory status of microplastics in Europe. The main aim is to address the gap in the Canadian policy structure and draw conclusions where we stand in terms of implementation of the policies as compared to the EU Plastic Directive. The EU Plastic Directive addresses microplastics as a part of its waste legislation focuses on mitigation measures (Brennholt et al. 2017a). The EU Plastic Directive is a running model released in 2018 detailing the list of actions to be taken to decrease plastic waste and litter. Following are some of the policy option mentioned in the paper (Brennholt et al. 2017a & SAM, 2018).

- Actions to reduce single-use plastic
- Actions to tackle sea-based sources of marine litter
- Actions on Oxo-plastics
- Actions on microplastics in particular by examining their unintentional release from tires, textiles and paints
- Developing a certification scheme to reduce pellet spillage

Thorough comparative research was carried out on other policy models accessible worldwide and within Canada on plastic waste disposal compared to the EU to comprehend and draw conclusions on the jurisdictional frameworks. Despite essential efforts in the past

to address (micro)plastic pollution such as banning microbeads, attempting to ban single-use plastics at the 2018 G7 conference, and releasing CCME's 2018 Zero Plastic Strategy Plan, Canada is still lagging attaining its sustainable growth objectives. There is a disparity between the theoretical dimensions and the execution of the waste management strategies in Canada compared to the EU.

v. EXPERT INTERVIEW

A semi-structured interview was performed with the subject matter expert to clarify microplastic pollution-related strategies and also to comprehend the current status and execution of the single-use plastic ban. This interview was done to obtain experts viewpoints on the adoption of the circular economy at the federal level inspired by the successful models of a circular economy for plastics in the EU. The interview was open-ended to obtain more information related to the federal government's efforts to keep track of the chemicals used in plastic production for further chemical contamination. The main goal for the interview was to expand knowledge and understanding about the microplastic impacts and the circular economy projects being taken by the federal government at the national level and to clarify further the aspects of designing a strategy to ban single-use plastic at the national level. This interview also helped to give an insight into what role a circular economy plays in getting rid of the microplastic menace. The meeting was audio-recorded, and the transcribed later. The interview gathered data is integrated into the document and helps fill the gap in the research. The sample interview and the consent is provided in the appendices in the end.

vi. SCOPE AND LIMITATIONS

The primary goal of this research is to investigate the impact of the microplastics on aquatic ecosystems (marine and freshwater) in Canada and to explain policy options available around the world to ban single-use plastic. An attempt was made to compare the plastic management strategies available in other jurisdictions to convince the federal government to impose a nationwide ban on single-use plastic. There is a lack of effective waste management policy that is aimed explicitly at banning single-use plastic in Canada. A ban on microbeads has already been imposed successfully in July 2018. Many jurisdictions around Canada lacked data on their current strategies for reduction of waste and reduction of single-use plastics. The data presented in the following study is mainly collected from the baseline information available from various sources and is not leading to any conclusion. As per previous research, there is limited information available on the policies related to microplastics in Canada and their impacts on the freshwater ecosystems.

CHAPTER 3: LITERATURE REVIEW

Plastic became instantly famous since the time of their mass production in the 1940s because of their durability and broad applicability (Thompson et al. 2009). They have become indispensable in many areas of modern life, being used for clothing, storage, transportation, packaging, construction and various consumer goods (Isensee & Valdes, 2015). They are lightweight, durable and cheap, which make them suitable for the manufacturing of a wide range of products (Derraik, 2002). However, these same properties happen to be the reason

why plastics are a severe hazard to the environment (Derraik, 2002). Durability, unsustainable use, and improper waste management cause an extensive accumulation of plastics in natural habitats (Wagner et al. 2014).

i. DEFINITION OF MICROPLASTICS

Plastics can be found in two forms vast plastic wastes and small plastic pieces commonly known as microplastics. Larger plastic often called "macroplastic," breaks down into smaller plastic pieces called "microplastics." It is these smaller particles that are of particular concern in aquatic environments (both marine and freshwater) (IJC, 2016). The term "plastic" is used to define a sub-category of the larger class of materials called polymers that soften on heating, and can be moulded (GESAMP, 2015). These include both virgin plastic pellets (used for manufacturing of plastic objects), and the resins mixed (or blended) with numerous additives to enhance the performance of the material (GESAMP, 2015). However, the word 'microplastics' is commonly used to define the size of plastic particles varying from 1 nanometre (nm) to 5 mm (mm) (UNEP, 2018b).

Plastics are commonly known as 'macroplastic' is a synthetic polymer chains of molecules linked together (Thompson et al., 2009).
'**Microplastics'** are the synthetic polymers measuring the size <5mm in diameter (Arthur et al., 2009).

Fragmentation due to ultraviolet radiation, mechanical abrasion and ocean temperatures are the factors that turn plastic into plastic fragments called microplastic (Ogunola et al. 2019). There has been no clear definition of microplastics established so far. The term microplastics was first coined in 2004 to explain the accumulation of plastic debris in the aquatic ecosystems by Thompson et al., and Arthur et al., in 2009 proposed the upper limit

to the size of the microplastics as <5mm (Frias et al., 2018). However, there is still no agreement on the upper and lower size limits to microplastics, even though the most used definition is the one proposed by Arthur et al., 2009 (Frias et al., 2018).

ii. SOURCES OF MICROPLASTICS IN THE AQUATIC ENVIRONMENT

As described in the literature, microplastics enter the aquatic environment from various sources. They may be released into the marine environment by accidental spillage of raw materials such as pellets (Thompson et al. 2009) or by anthropogenic activities involving inappropriate disposal of plastic waste such as plastic straws, cups or bags (GESAMP 2015, Thompson et al. 2009). A study by Driedger et al. in 2015 revealed that the largest concentration of microplastics in the Huron River in Michigan is from all the Great Lakes. Here, more than two dozen aquatic species were studied, and microplastics were found in each subject (Driedger et al. 2015). The microplastics are recently discovered to be concentrated in some locations after entering into the ocean, most popularly known as ocean gyres (GESAMP, 2015). The major release of plastics to the environment are the result of improper waste management and inappropriate human behaviour, for example, littering (Barnes et al. 2009). These plastic wastes enter the aquatic ecosystem through the wind, stormwater runoff or illegal dumping of plastic material (Barnes et al. 2009). The potential source includes wastewater treatment plants, beach litter, fishery, and runoff from industrial plastic production may be an additional source (Wagner et al. 2014).

Figure 2 below by Boucher et al. 2017 explains the different source of entry for the microplastics into the aquatic environment. The maximum amount of microplastic as per them is coming from synthetic textiles which accounts for the 35% of the global microplastic release into the oceans as mentioned in the IUCN 2017 report by Boucher et al. 2017. It is important

to note that the three major contributors to the microplastic pollution according to the report are tire abrasions (28%), city dust (24%) and synthetic textiles (35%) (Boucher et al. 2017).

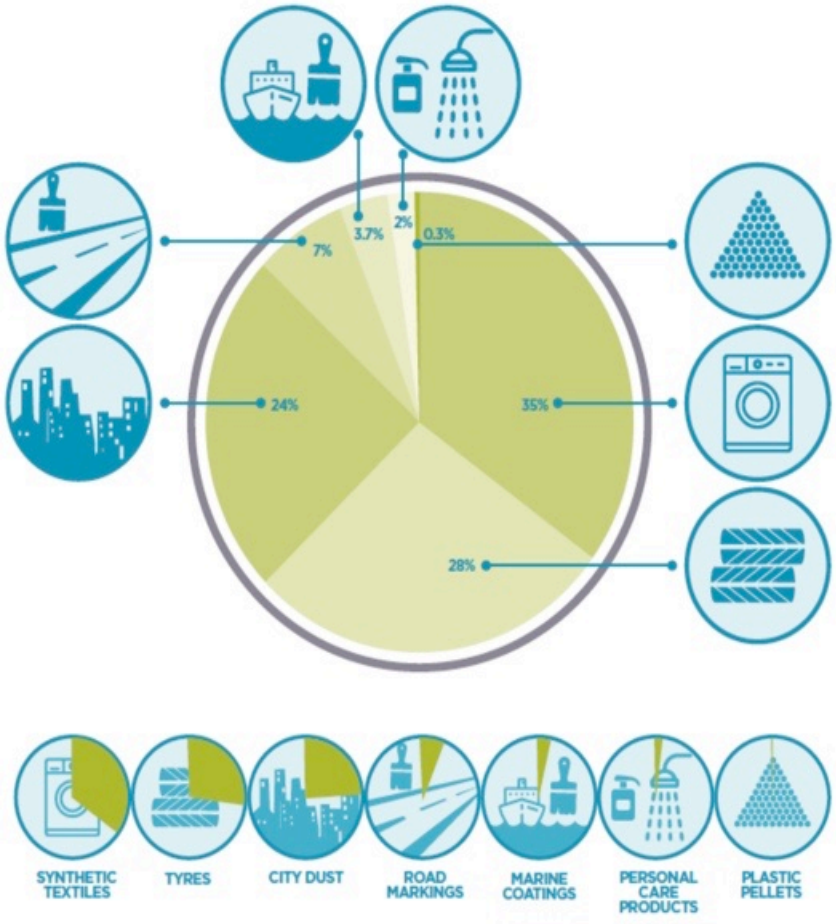

Figure 2: Different sources of the global releases of microplastics to the aquatic environment Source: Extracted from Boucher et. al. 2017https://portals.iucn.org/library/sites/library/files/documents/2017-002.pdf

Table 1 and 2 summarizes both land and water-based sources of microplastics in the environment. Most of the aquatic plastic waste is produced as a result of improper dumping from land-based sources.

Table 1: Land-based sources of microplastics

PRODUCT	ORIGIN	IMPACT
Straws, plastic cups, plastic containers, plastic bags, cigarette butts and polystyrene packaging	Inappropriate dumping, storm-water runoffs	• This type of waste cannot be recycled and takes about 1000 of years to decompose (Geyer et al. 2107). • Many marine animals and sea birds die every year by ingesting them mistakenly (Derraik, 2002). • Styrene has shown to cause cancer and immune-system impairment among animals (Gallo et al. 2018).
Sewage effluent	Sewage treatment plants	• The tiny pieces of plastic cannot be filtered through sewage plants and finally find their way into the water bodies (Hogue, 2013).
Microfibers	Washing machines	• Ingested by the fishes in the marine ecosystem and blocks their digestive tracts (Thompson et al. 2009, Derraik, 2002). • Formaldehyde used in making pressed fabric is considered to be carcinogenic (Bosetti et. al. 2008).
Tyre fragmentation	Car driving	• According to IUCN report by Boucher et. al. the abrasion of tires emits 17,000 tonnes of particles that ends up into the environment in the form of microplastics (Boucher et. al. 2017).

Scientists suspect that wastewater treatment plants could be a significant point source of microplastics in freshwater bodies and oceans as plastic debris are difficult to capture because they have a tendency to float (Hogue, 2013). The study of wastewater treatment plants confirms that treated sewage as the critical source of microplastics (Kay et al. 2018). There are alternative routes for microplastics to enter aquatic ecosystems from spillage of plastic pellets that are used as a feedstock for the production of the larger items for industrial

purposes (Bergmann et al. 2009). Recent studies have also shown that discarded fishing equipment act as a significant source of microplastics accumulating along shorelines (Barnes et al. 2009).

Table 2: Water-based sources of microplastics

PRODUCT	ORIGIN	IMPACT
Plastic pellets	Accidental spillage during shipping	• Mixed with marine debris these plastic pellets can be ingested by the marine animals and can block their digestive tracts thereby causing malnutrition and starving (Thompson et al., 2009).
Fishing gear	Discarded and abandoned during fishing activities	• Being non-biodegradable they break down into smaller pieces called microplastics that fishes ingest on mistaking them as their food (Barnes et al., 2009). • Risk of entanglement in marine animals causing death due to suffocation (Barnes et al., 2009).
Land-based sources such as Plastic cups, straws, plates and straws	Due storm water runoffs, winds, illegal dumping, beaches and other recreational activities, or industrial waste dumping (Wagner et al. 2014)	• Littering of water bodies, • Chemical leaching • Breakdown of macroplastic into microplastics with the help of microbial activities.

iii. Types of microplastics

Plastic debris is generally classified according to their size, origin, shape, composition (Driedger et al. 2014). Figure 3 depicts a graphical breakdown of the different types of microplastics. Microplastics are divided into primary or secondary, based on their source of

origin. Primary microplastic includes the products originally manufactured in smaller shape and size (sizes between 1 µm and 5 mm) for a specific activity (Lassen et al. 2015). They are sometimes intentionally added to the products of personal use. These include (GESAMP, 2015);

a. Microbeads added intentionally to personal care products such as toothpaste, facial scrubs,
b. Spherical or cylindrical virgin resin pellets or Nurdles are widely used during as a raw material in the manufacture of other plastic products
c. Microfibers, tiny strands of synthetic fibres released from the synthetic clothes into the washing machines.

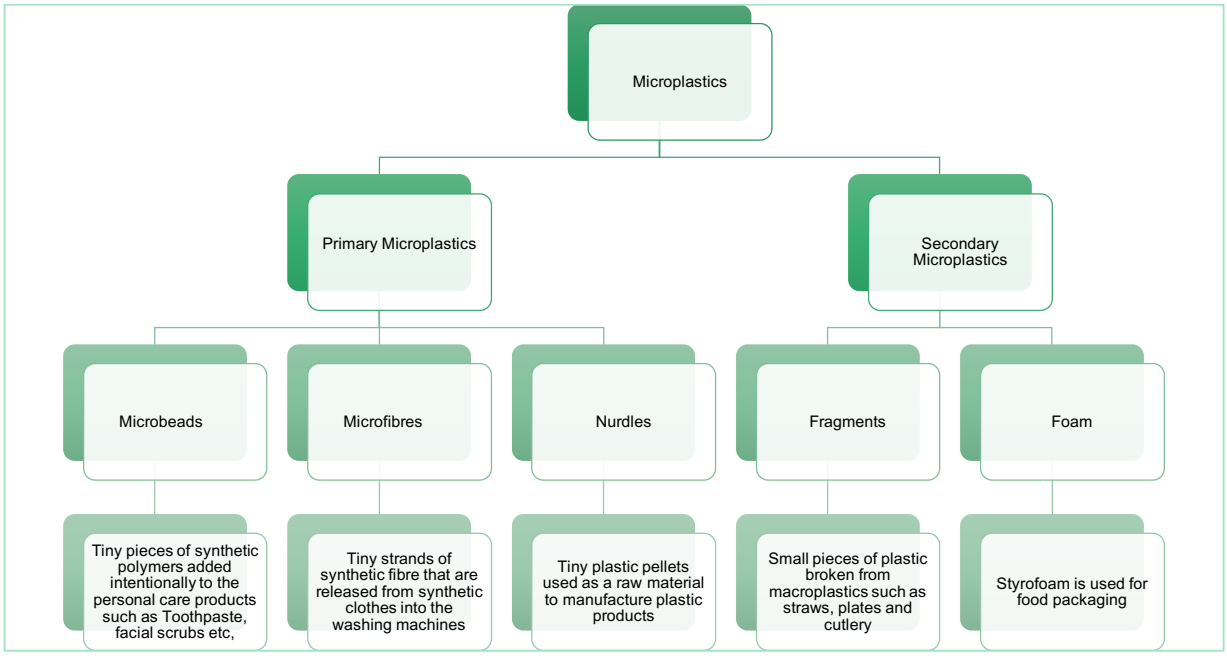

Figure 3: A graphical breakdown of different types of plastics Source: GESAMP, 2015, The Government of Canada, 2018

Secondary microplastics are the debris of macroplastic (straws, plastic bottles, or cups) that are broken down into smaller fragments with the help of UV (ultraviolet) radiations, wind, waves or microbial activities (Lassen et al. 2015). These include; (Lake Ontario Waterkeeper, 2016)

a. Fragments, pieces of macroplastics such as plastic plates, cutlery, straws and water bottle broken down into smaller fragments through sunlight, waves or microbial activities.
b. Foam, styrofoam used in food containers, cups and packaging material released breaks down into smaller pieces. There are no regulations to control their impacts on the environment, and most of the municipalities in Canada do not recycle these products.

iv. Physical impact of (micro)plastic on aquatic environment and human population

Figure 4: Pieces of microplastic found in the gut of fish Source: http://www.sccwrp.org/news/science-workshop-jump-start-planning-microplastics-monitoring-california/

a. Ingestion by the organisms

We often see a picture of aquatic animals entangled in the plastic litter discarded inappropriately into the environment. But there is a vast majority of plastic that never

biodegrades and breakdown into smaller pieces. Ingestion of these smaller pieces of plastics is the most common cause of death of aquatic animals (figure 4 & 5). Ingestion of microplastics is the most common problem amongst the marine organisms. Since microplastics are similar in shape and size of the zooplankton and hence are highly likely to be ingested by the fish, birds and invertebrates (Bouwman et al. 2018; Thompson et al. 2015; Derraik 2002). This ingestion of microplastics by the animals is the primary area of concern as it can be a health hazard in some instances. These tiny fragments may get clogged in the digestive system and may also be taken from the gut into other body tissues (Barnes et al. 2009; Derraik 2002).

Figure 5: Pieces of microplastic found in the body of a sea bird Source: https://www.npr.org/2014/06/17/322959714/plastics-dont-disappear-but-they-do-end-up-in-sea-birds-bellies

Among the most apparent consequences of microplastic ingestion by fish is the physical blockage of the digestive organs and interference with the feeding (Jovanovic", 2017). The physiological interference can be observed when microplastics directly interfering with the immune system of freshwater fishes and reduces the ability of the predator to perceive (Pinheiro et al. 2017). Many marine animals are either drawn to or accidentally entangled in the discarded fishing nets and lose their lives from commercial fishing activities (Gregory,

2009). Entanglement is considered to be one of the major cause of chronic injury or death in marine animals (Nelms et al. 2016).

The physical impacts of microplastics are also associated with the transfer of contaminants to higher levels of the food chain. The toxic contaminants are discovered to be transferred to greater trophic food concentrations. The organisms at the higher trophic levels (e.g. seabirds) are ingesting highly increased concentrations of hydrophobic contaminants via their preys (e.g. fish) (Teuten, 2009). Seafood for human consumption may also be contaminated with microplastic (Nelms et al., 2016); however, its existence as a contaminant in the human diet and the effects of microplastics on food for human consumption are unknown (Wagner et al. 2014). Microplastics have been reported in the Shellfish (some kinds of which are common in freshwater) and in some processed food and beverages such as sugar, beer and salt (Wright et al. 2017).

b. Economic losses

Plastic may sometimes lead to economic losses to the country by creating negative impacts on the tourism industry (Kibria, 2017). Discarded plastic material around the shoreline can negatively impact shipping, energy production, fishing and aquaculture resources (Kibria, 2017). There are also concerns about chemical contamination, invasive species spread by plastic fragments, and economic damage to the fishing and tourism industries in many countries, for example, fouling fishing equipment and polluting beaches (U.N., News, 2014). The UNEP report states that plastic waste causes US$13 million worth of financial damage to marine ecosystems each year as the concerns grow over microplastics (U.N. news, 2014). The global marine litter and plastic pollution problem, as well as fears of increasing consumerism and waste, continue to gain media attention worldwide (CCME,

2018). It is further mentioned in the UNEP report that over 30 percent of the natural capital costs of plastics is due to greenhouse gas emissions from raw material, extraction and processing and the marine pollution is the most considerable downstream cost (UNEP, 2014a). The coastal communities are facing increased expenditures on beach cleaning, public health and waste disposal (GESAMP, 2015). The shipping industry is impacted by higher costs associated with fouled propellers, damaged engines, and managing wastes in harbours (UNEP, 2017c). The finishing industry is affected by reduced catch and damaged gear. There are economic losses to the seafood industry due to the ingestion of plastic by the fishes that leads to less consumption of seafood (GESAMP, 2015).

v. Chemical impact of microplastic on aquatic environment and human population

Along with the physical impacts, plastics debris also have chemical effects on the environment by transferring toxic chemicals or contaminants up into the food chain (Teuten et al. 2009). The toxic chemicals inserted in the plastic during the manufacturing process can easily migrate or diffuse into the environment causing adverse effects on the freshwater ecosystem (Pinheiro et al. 2017). In plastics manufacturing, an increasing number of chemicals are increasingly used as additives in technology development. However, some, such as phthalate plasticizers and brominated flame retardants, are possibly dangerous and have been linked with carcinogenic and endocrine-disrupting impacts (Barnes et al., 2009). Many chemical additives are added intentionally to enhance the properties of plastic such as durability, rigidity, U.V. resistant malleability or waterproofness characteristics (UNEP, 2018d). These modified plastic products, such as fishing nets, bottles, pipes or packaging products, release chemicals into marine organisms when they ingest them (UNEP, 2018d). Potential adverse effects, at high enough concentrations, may include immunotoxicological

responses, reproductive disruption, abnormal embryonic development, endocrine disruption, and altered gene expression (UNEP, 2016b). Textile dermatitis is the most frequent cause of formaldehyde resins being used on fabrics to impart wrinkle-free resistance (Rao et al., 2004).

Teuten et al. 2009 observed through series of experiments that contaminants like polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons, petroleum hydrocarbons, and hexachlorinated hexane (HCH) transferred from plastics to birds, fishes and other aquatic animals that fed upon this plastic debris mistaking them as their food. The inappropriate disposal of plastic waste causes toxic chemicals like phthalates and Bisphenol A (BPA) leach into the freshwater ecosystem (Thompson et al. 2015). According to Teuten et al., the transfer of contaminants occurs in 3 ways; inhalation, dermal sorption and ingestion. The most significant transport route will vary according to the organism and the physio-chemical properties of the contaminant (Teuten et al. 2009). But in most of the species, the most common transfer of contaminant occurs through ingestion (Teuten et al. 2009). There is considerable concern about the adverse effects of these chemicals on wildlife and humans (Thompson et al. 2009). The research has demonstrated that chemicals like phthalates and BPA both can affect the development and reproductive activities in some wildlife species (Oehlmann et al. 2009, Meeker et al. 2009). Even though humans are well exposed to these chemicals, the risk of exposure to plasticized chemicals to human health is the most understudied subject (Meeker et al. 2009).

Plastic packaging is another major contributor to the leaching of chemicals from plastic to the food that we eat. The use of plastic for the packaging of food products in the supermarkets is on the rise. About 60% of the plastic packaging is used food and beverages while the rest

covers cosmetics, household, apparel, shipment packaging and healthcare industry (Groh et al. 2018). Many chemicals and solvents such as adhesives or coatings used to make plastic or plastic packaging are found to be hazardous and have significant concerns about occupational health (Groh et al. 2018). There are some non-intentionally added substances (NIAS), such as impurities, oligomer, or degradation products (Groh et al. 2018). These chemicals act as a barrier to the recycling or reuse process of the packaging products.

Anderson et al. in their 2016 paper "Microplastics in the aquatic environment: Implications for Canadian ecosystems" have mentioned how the potential toxicity of the microplastics originates from mainly three pathways namely stress of ingestion, leakage of chemicals from the plastics and the exposure to the contaminants associated with microplastics (for example persistent organic POPs). It is unknown whether microplastics can have effects on smaller aquatic organisms, consistent with effects caused by macroplastics exposure in larger organisms (e.g., internal damage due to ingestion, choking hazard, entanglement) (Anderson et al. 2016).

CHAPTER 4: CANADIAN POLICY FRAMEWORK TO MITIGATE THE IMPACT OF MICROPLASTICS

The impact of the microplastics on aquatic ecosystems are now well known, but there are relatively few policies available to mitigate their toxicity in the environment (Pettipas et al. 2016). Despite consideration by the International Joint Commission, very few regulatory instruments have been developed to address the freshwater microplastic litter, because of

lack consensus so far on the definition of microplastics (Brennholt, 2018b). Existing policies towards waste management are more focused towards banning microbeads, which was recently implemented successfully in July 2018 in Canada (Pettipas et al. 2016). The ban seems to be too narrow to address the issue of microplastic. The federal 'government's recent announcement to phase out single-use plastic by 2021 is the first step towards having a plastic-free environment. However, microplastic is not yet addressed as a broader issue in any of the strategies. The two-part strategy was announced in June by prime minister Justin Trudeau as;

- Ban harmful single-use plastic by 2021 such as straws, cups, plates and packaging products based on scientific evidence
- Work with the provinces and territories to help companies responsible for their plastic wastes.

This chapter focusses on the study of the Canadian policy framework to mitigate the impact of microplastics on aquatic ecosystems. Through this chapter, the existing policies related to microplastics management such as CEPA,1999, have been reviewed to get to know their effectiveness in managing plastic waste, especially in the case of microplastics. An interprovincial jurisdictional comparison is made in the end to understand the current status of the federal government in mitigating the impact of microplastics.

i. Background

The evolution of environmental laws in Canada has been through many changes under different governments. The protection of the environment, with the help of laws, gained precedence only in the past few decades. The legislative authorities to address the environmental concerns shared amongst federal and provincial governments (Valiante,

2009). In Canada, the environmental law is a statute and body of common law used by both the federal and provincial governments to solve their environmental issues (Valiante, 2009). Federally there are many Acts to address the environmental problems such as the Environmental Assessment Act (EAA) or Fisheries Act. However, the Canadian Environmental Protection Act (CEPA) is the principal federal statute (The Government of Canada, 2017a). The Canadian Environmental Protection Act, 1999 (CEPA 1999) is designed to protect the environment and human health, and thereby to contribute to sustainable development, through pollution prevention (The Government of Canada, 2017b). The Government of Canada has to administer CEPA 1999 in a manner that promotes enforceable pollution prevention approaches (The Government of Canada, 2017b). The techniques and practices used to implement pollution prevention can vary from sector to sector, but generally focus on areas such as; (The Government of Canada, 2017b)

1. substituting materials and feedstock with less harmful alternatives;
2. product design/reformulation to eliminate waste and pollution;
3. changes to improve process efficiency;
4. on-site reuse and recycling;
5. training staff in safe handling and storage;
6. purchasing techniques to reduce waste,
7. implementing equipment modifications; and
8. operating efficiencies/clean production methods.

The provinces and territories of Canada deal with environmental issues under their constitutional rights concerning land and water. The federal government passes the legislation to deal with interprovincial and federal matters. Assessment of both new and existing substances is the joint responsibility of Environment Canada and Health Canada (Environment and Climate Change Canada, 2005). For this purpose, the present study will be more focused on the CEPA 1999. CEPA 1999 aims to protect the environment and human

health from risks posed by substances, including those new to Canada since 1987 (new substances), as well as the chemicals in use before 1987 (existing substances).

ii. Federal policy framework: Canadian Environmental Protection Act (CEPA)

The Canadian Environmental Protection Act, 1999, first came into force in March 2000 and since then has been updated with some amendments (The Government of Canada, 2017b). The Act introduced as the leading law to tackle the issues of pollution in Canada. The Act is defined as; (The Government of Canada, 2017b).

> "An Act respecting pollution prevention and the protection of the environment and human health to contribute to sustainable development"

The primary purpose of CEPA 1999 is to contribute towards sustainable development by achieving the protection of the environment from toxic substances. Many topics covered under this Act ranging from prevention of pollution to control of toxic substances. As per the Act, any substance genetically produced or modified should be tested for toxic substance before being introduced to the Canadian markets (The Government of Canada, 2017b). And if they are found to be toxic, they should be included in the list of toxic substances with some conditions determined by the Canadian Government that might prohibit the manufacture, use or import of such toxic substances (The Government of Canada, 2017b). This Act also contains directives on adequate waste management to safeguard the ecosystem against land and water operations.

Within the Federal Government, CEPA 1999 is the primary element of the legislative framework for protecting the Canadian environment and human health (The Government of Canada, 2017c). Part 4 of CEPA 1999 addresses environmental protection through pollution prevention planning provisions which, if implemented, can minimize the need for additional regulations or other government interventions to manage the risks to the environment and human health by Schedule 1 substances (The Government of Canada, 2017b). CEPA 1999 provides Canada with an opportunity to deal with the international community in the prevention of pollution globally. In chapter 3 of CEPA 1999, certain guiding principles have been set as the preamble (figure 6) by the Government of Canada (The Government of Canada, 2017b). A few of them are;

1. **Sustainable Development:** The government of Canada's environmental protection aims to develop strategies for the sustainable development that involves the meeting the needs of the present generation without compromising the needs of the future generation.
2. **Intergovernmental Cooperation:** The guiding principles, as shown as in figure 5, focus on pollution prevention with the help of the ecosystem approach that involves inter-governmental cooperation and ultimately leading to sustainable development.
3. **Pollution Control:** One of the main pollution prevention responsibilities under CEPA 1999 is the management and control of substances listed on Schedule 1 of the Act part 4 of which addresses environmental protection through pollution prevention planning provisions.
4. **Polluter Pays:** CEPA incorporates that polluter should bear the responsibility of the pollutants released. It requires the polluter should pay the cost for all the pollutants and wastes being generated.
5. **Ecosystem Approach:** Ecosystem approach should be applied to control the environmental, social and economic effects of any substance. This includes the understanding of the interrelationship between air, water, soil, wildlife and human activities.

6. **Science-based Decision:** Science-based decisions to be considered to prevent the adverse effects of the substances on the environmental and socioeconomic growth.

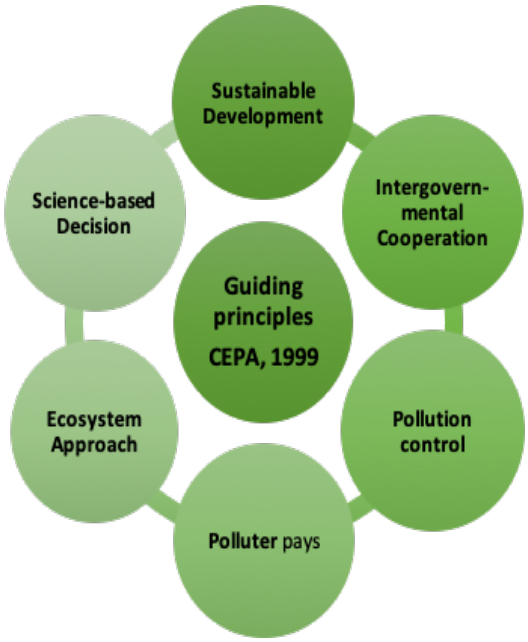

Figure 6: Guiding principles of CEPA, 1999, Source: http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=E00B5BD8&offset=3&toc=show

Guiding principles like Sustainable Development, Pollution Control and Ecosystem Approach function as a guide for the Federal Government to design and control the presence of microplastics in the environment as they help recognize damaging chemicals using a holistic approach. Environmental protection and sustainable developmental should remain the utmost priority of the Federal Government while developing a practical regulatory framework for microplastic pollution. Chapter 5 of CEPA 1999 deals with the existing substances program to give an overview of the process of identification and prioritization of toxic substances for assessment. The management of (micro)plastics is closely related to various existing land and as well as water-based policies.

The substances to become eligible for the list of existing substances are assessed under seven categories of existing substances list. These categories are:

1. Domestic Substances List (DSL)
2. Industry Information
3. Information Exchange and Review of Information
4. Nomination for Priority Substances List (PSL)
5. New Substances Notification
6. Emerging Science and Monitoring
7. International Assessment and Data Collection

There are currently 23,000 substances on Canada's domestic substances list categorized under Section 73 of CEPA 1999 (The Government of Canada, 2017c). The ministers are accountable for undertaking a risk assessment to recognize the adverse effects of the new substances. A substance is considered harmful according to the criteria set under Section 64 of CEPA 1999 if the substance; (The Government of Canada, 2017c)

- Has Immediate or long term harmful effects in the environment
- Poses or may pose a danger to the environment on which life depends
- Is or may be a danger in Canada to human life or health

The substances that meet the above criteria are included under Schedule 1 Toxic Substances list of CEPA 1999. These substances are persistent, bioaccumulative and produced primarily as a result of human activity and are considered to be the most dangerous (The Government of Canada, 2017c). Hence, their release to the environment and human exposure to these harmful substances should be reduced to the minimum (The Government of Canada, 2017c).

iii. Terrestrial and Aquatic Waste Management Policy (federal vs provincial)

The most critical step towards maintaining the health of the ecosystem is to protect both aquatic and terrestrial ecosystems from the adverse impact of inappropriate plastic waste disposal. Effective waste management policies are required to address the problem of (micro)plastic litter from terrestrial and aquatic activities. With the advancement of technology, many anthropogenic activities contribute to both land and water-based plastic debris. The adverse impacts of plastic waste have slowly been recognized around the world with many countries coming forward with strategies to adopt a ban on single-use plastic. While management strategies for both macro and microplastics lack in Canada, a few global initiatives do exist that further knowledge on plastic contamination, disposal, and pollution prevention (S. Pettipas et al., 2016). The larger plastic debris is visible and can have economic and ecological impacts, but the micro pieces of plastics such as microplastics in the oceans have emerged as the significant international area concern (GESAMP, 2015). Many land-based sources contribute to the formation of microplastics in aquatic ecosystems. Some of these are shown in table 1.

In Canada, the federal, provincial and territorial governments share the responsibility for waste management (The Government of Canada, 2017c). It is the responsibility of the federal government to provide funding for the projects and action plans to reduce waste and manage plastic pollution. The federal government further collaborates with the provincial, municipal, territorial and indigenous groups under Canadian Council of Ministers of Environment to help improve waste reduction policies and practices across Canada (The Government of Canada, 2017c). However, there are some acts and regulations under the federal government to address the issues related to waste management in waters such as the Fisheries Act, 1985.

Fisheries Act can act as a useful statute to control microplastic pollution if they are proven to be harmful to fishes.

The majority of the plastic litter in the aquatic environment is coming from land-based activities such as inappropriate garbage dumping, recreational activities on the beaches, improper industrial practices or stormwater runoff. The most problematic waste to manage is the windblown litter on the extreme weather days. Environment Canada is responsible for developing and implementing policies. Environment Canada is also responsible for the regulation to manage the risks of toxic waste, generated as a result of improper dumping of plastic waste, at the federal level under CEPA 1999. The federal rules are applied to all lakes, rivers, oceans under Canadian jurisdiction and do not vary depending on whether the waters federally or provincially owned authority (Becklumb, 2013). Schedule 1 of CEPA 1999 provides the list of the toxic substances in which plastic microbeads is included at number 133. Single-Use plastic contains certain chemical additives that can prove harmful to the environment. Most microplastic particles are composed of polyethylene, polypropylene and expanded polystyrene (GESAMP, 2015) and many of these are not included in the list of toxic substances under Schedule 1 of CEPA 1999. The control, as well as regulation or elimination of toxic substances, comes under the federal jurisdiction of CEPA 1999, that determines whether a substance is toxic or not. The federal government is also accountable for waste management and other relevant regulations such as the Fisheries Act to regulate the release of any toxic substances to water bodies that may have adverse effects on aquatic ecosystems. This type of management requires a lot of scientific research and data. Listed below are some of the efforts made by the provincial and federal government to deal with plastic waste management.

a. Federal Initiative

Strategy: As an initiative towards Zero waste policy, the federal government has introduced Greening Government Strategy in 2015 which is consistent with the United 'Nation's 2030 Agenda for Sustainable Development (The Government of Canada, 2018d). Under Greening Government Strategy, the government has set agenda to take steps to reduce the environmental impact of waste by (The Government of Canada, 2018d)

a. Diverting at least 75% by weight of all non-hazardous operational waste by 2030;
b. Diverting at least 90% by weight of all construction and demolition waste and striving to achieve 100% by 2030;
c. Minimizing environmentally harmful and hazardous chemicals and materials used and disposed of in real property operations;
d. Reduce single-use plastic in meetings, operations and events;
e. Procure sustainable plastic products

"While single-use, plastics may sometimes be necessary for accessibility, health, safety or security reasons, in many situations, they can be avoided entirely or replaced by more reusable, compostable or recyclable alternatives. Alternatives that serve the accessibility and health needs of public servants, such as disposable bendable straws, will still be provided when needed."

The reduction of single-use plastic in the meetings, operations and events set as one of the main objectives under the strategy, no efforts are being made to bring a complete ban on single-use plastic. The document for Greening Government Strategy states that (Government of Canada, 2019d).

Action: It has been mentioned in the progress report that the government has failed to achieve its goal to reduce waste and minimize the environmental impacts of the assets throughout their lifecycle.

Strategy: In June 2018, Canada launched OCEAN PLASTIC CHARTER at the G7 meeting to endorse banning of single-use plastic along with France, Germany, Italy and the UK. In the OCEAN PLASTICS CHARTER, the leaders, of Canada, France, Germany, Italy, the UK and the EU commit to moving towards a more resource-efficient and sustainable approach by agreeing to work with industry towards 100% plastic reusable, recyclable and recoverable plastics by 2030 (CCME, 2018). The main highlight of the OCEAN PLASTIC CHARTER is to take action towards a resource-efficient lifecycle management approach to plastics in the economy by; (Oceans Plastic Charter, 2018).

a. Sustainable design, production and after-use markets
b. Collection, management and other systems and infrastructure
c. Sustainable lifestyles and education
d. Research, innovation and new technologies
e. Coastal and Shoreline action

Action: The government of Canada recently announced a ban on single-use plastics, and we welcome this move by the government. The federal government announced the ban of some plastic under the single-use plastic ban, which is not going to be enough because it's not a problem that can be solved with one measure (Prof. Buonsante, Personal Communication, 2019). However, there are certain loopholes in the regulation that needs to be addressed as early as possible.

Strategy: There are generally two types of waste management strategies linear and circular. In linear waste management (figure 7), the manufactured products after moving from a series of stages finally end up into the landfills. In the case of a circular economy (figure 8), also known as closed-loop waste management, the manufactured product is reused, reduced or recycled. However, this has not been implemented federally. Closed-loop recycling is most

practical when the polymer constituent can be (i) effectively separated from sources of contamination and (ii) stabilized against degradation during reprocessing and subsequent use. (Hopewell et al., 2009). The European Commission adopted a circular economy in 2015 where resources are used, and the proposed actions will contribute to "closing the loop" of the product life cycles from production and consumption to waste management and the market for secondary raw materials (Brennholt et al., 2017a).

Action: The current flow of material and energy in the Canadian economy is mostly linear where most of the waste ends up in landfills. There are currently almost 2000 operating landfills across Canada that accept municipal solid waste (CCME, 2014). A significant drawback to landfills from a sustainability aspect is that none of the material resources used to produce the plastic is recovered—the material flow is linear rather than cyclic (Hopewell et al., 2009). Approximately 79% of the total waste (including plastic polymer) produced in Canada is landfilled that lay their releasing chemicals and contaminating the soil and groundwater. Waste diversions can tell how much waste is diverted from the landfills through recycling or other waste reduction activities.

Figure 7: Linear Waste Management Strategy

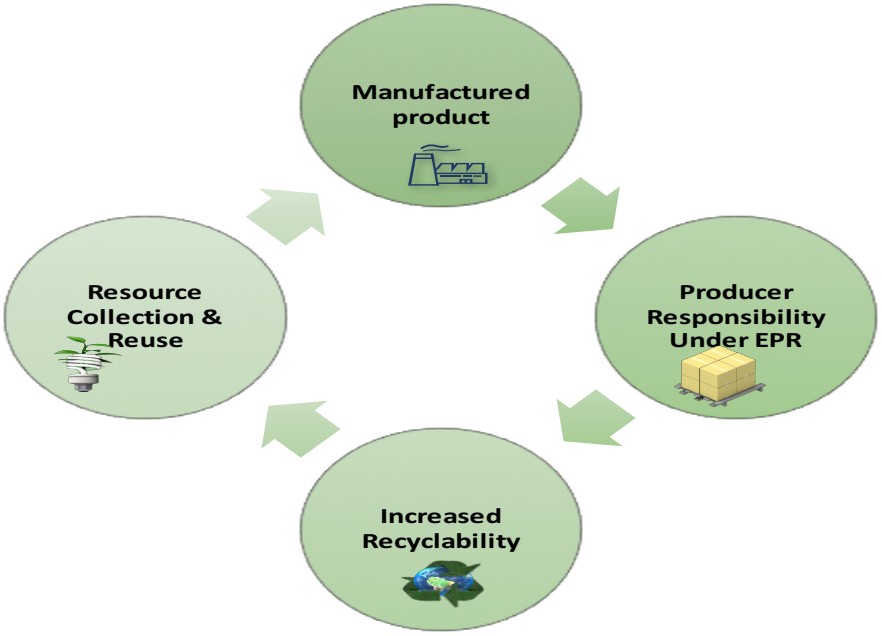

Figure 8: Closed Loop Strategy

Strategy: The loss of fishing gears and accidental spillage of pellets (Nurdles) during their transport through ships is another major cause of accumulation of plastic and microplastic waste in the aquatic ecosystem. According to the World Society for the Protection of Animals (WSPA), an estimated 640,000 tonnes of fishing gear is left in our oceans each year. These fishing nets are sometimes addressed as Ghost nets that often travel long distances from their point of origin and accumulates at a location which are now being known as garbage gyres (WSPA, 2014). Canada works to "promote responsible ocean governance and the stewardship and sustainable use of coastal and ocean resources in Canada and around the world (S. Pettipas et al. 2016).

Canada joined the Global Ghost Gear Initiative to get the abandoned fishing gears out of the oceans, is the 13th nation to join the global alliance (Globe and Mail, 2018b). Under this, clean-up initiatives are being taken to procure the lost and abandoned fishing gear and facilities. However, there are specific barriers to this program, as it required some trained

personnel for the diving operations to recover the lost or abandoned gear. And also, there is a lack of proper regulation at the federal level on dealing with abandoned fishing gear. The Fisheries Minister Jonathan Wilkinson in an interview to Globe and Mail in 2018 said that;

> "fishers on the East Coast trying to remove ghost gear are often prevented from doing so because existing regulations prevent the removal of gear you don't own."

Action: Canada's Fisheries department says that although some regional efforts are being made, no national program exists to remove abandoned gear from the country's waters.

b. Municipal Initiative

The current waste management responsibilities in Canada are shared amongst the federal, municipal and territorial governments, but the management of toxic substances falls under federal jurisdiction (Becklumb, 2013). There are many chemicals knowingly or unknowingly added to the plastic products during their manufacturing stage to increase their persistence. These chemicals have proven to be leached into ecosystems and having adverse impacts on the plants, wildlife and humans. Many counties are working at their level to regulate the threat of (micro)plastic that has emerged over the past few decades and has adversely affected our lives.

Under 'Canada's Council of Minister of Environment (CCME) the ministers from different jurisdictions adopted a vision for waste and in 2018 endorsed the Aspirational

Canada-wide Waste Reduction Goal and Canada-wide Strategy on Zero Plastic Waste (CCME, 2018). The current priorities under 'CCME's strategy include:

a. develop an action plan for zero plastic waste,
b. increase waste reduction and resource recovery, including food and organic waste
c. contribute to the transition toward a circular economy in Canada
d. promote approaches that shift responsibility from taxpayers to producers and users
e. reduce greenhouse gas emissions from the waste sector
f. improve waste management in rural, remote and northern communities

Listed below is a provincial breakdown of the efforts adopted by each jurisdiction to eliminate single-use plastic.

British Columbia (BC): Tofino municipality, BC has implemented a voluntary ban on single-use plastic. Towns like Rossland and Salmon Arm are considering similar bans. Vancouver became the first major city of Canada to ban plastic straws. Vancouver introduced plans for a complete ban on single-use plastic and styrofoam packaging in 2018 but not yet implemented. The city of Victoria has started charging a 15 cents levy for plastic bags. But the municipal leaders are calling for a complete provincial ban on single-use plastics. B.C. is the only jurisdiction with a successful running model of EPR (Extended Producer Responsibility) for waste disposal. B.C. started with a fully adopted EPR policy in 2004. The critical factors for successful implementation of EPR include; maintaining flexibility in program design, creating viable funding alternatives, aggressive enforcement to provide a level playing field, and adopting policies that maximize diversion of plastic waste from landfills, while minimizing waste generation, setting targets for reuse and recycling, promoting consumer awareness and convenience, involving local government jurisdictions, and monitoring outcomes (Driedger, 2008a).

Their 5R (Reduce, Reuse, Recycle, Recovery and Residual) hierarchy of wastes disposal (figure 9) supports the circular economy. Large bags of nylon – stripped from old fishing nets – are being collected in Steveston, B.C., in an attempt to put a dent in the tonnes of gear lost and discarded in the world's oceans every year that clog up harbours and endanger marine life (Globe and Mail, 2016a).

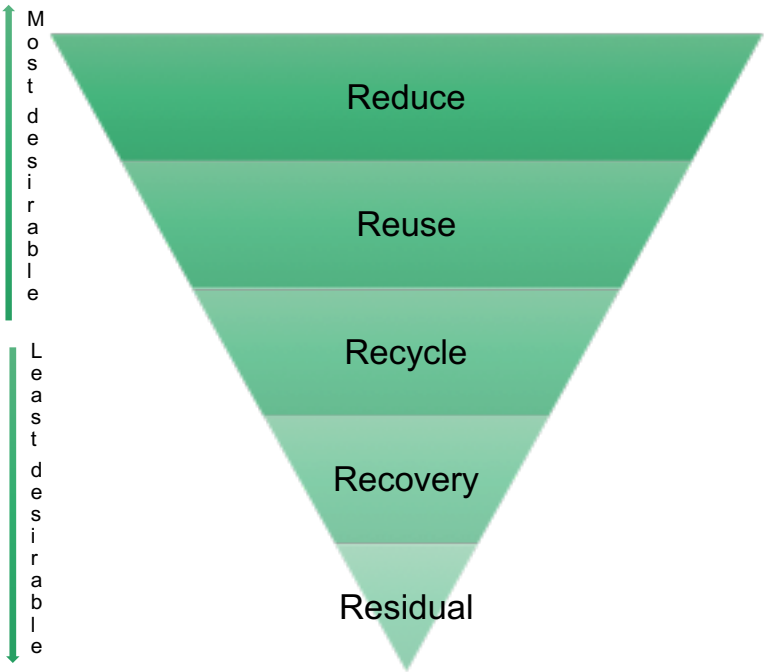

Figure 9: Waste Disposal Hierarchy in BC; Source: Extracted from the Government of BC

https://www2.gov.bc.ca/gov/content/environment/waste-management/zero-waste

Alberta (AB): The regional municipalities like Wood Buffalo and Wetaskiwin have implemented complete bans on single-use plastic. Although AB lacks any EPR policies in place, it depends heavily on the recycling of plastic waste for energy generation. AB follows the 4R policy of plastic waste disposal, i.e. Reduce, Reuse, Recycle and Recovery.

Saskatchewan (SK): SK is not considering any ban on plastic at the moment. The province delivers EPR policy for plastic waste management with partial approaches, and it

follows a linear approach for plastic waste disposal, which involves Take, Make and Disposal strategy.

Manitoba (MB): The province of M.B. depends on landfills and recycling operations for plastic waste disposal under the Waste Reduction and Prevention Act, 1990. Leaf Rapids and Thompson are the two municipalities that successfully adopted single-use plastic bag ban. However, there is no consideration for complete provincial ban single-use plastic at the moment. Efforts have been made to bring a ban to single-use plastic bags in Winnipeg also.

Ontario (ON): Ontario's legislation to ban single-use plastic is still pending. Ontario became the latest to consider a ban on single-use plastic by releasing a discussion paper. The highlights of the paper include; (Ministry of Environment, Conservation and Parks, 2019)

a. Diverting more waste from the landfill and reducing litter
b. Full producer responsibility which could save municipalities more than $125 million per year
c. Banning food waste into landfills
d. Expanding recycling programs

Cities like Greenstone and Sioux Lookout rescinded their ban bans in 2009 and 2011 respectively after residents' poll and overwhelming unpopularity with the residents and the retailers (Ministry of Ontario, Conservation and Parks, 2019). Ontario supports waste-free strategy for a circular economy by promoting more targeted EPR program, but it not implemented yet in the province.

Quebec (QC): Municipalities of Deux, Montagnes and Hudson has successfully implemented the legislation to ban single-use plastic bags. Montreal officially banned single-use plastics in 2012; however, it is yet to be implemented following a lawsuit filed by retailers

and plastic business owners. Huntington another municipality also banned single-use plastic that includes strict regulations for flyers inside the newspaper. Quebec is in a transition towards a circular economy for plastic waste disposal that contains directions for EPR policies. According to Prof. Buonsante, Quebec has an EPR system, but it is only financial where the producer pays the cost for the entire cost of waste management to the system.

Prince Edward Island (PEI): Prince Edward Island will become the first province to ban the single-use plastic bags under the Plastic Bag Reduction Act with effect from July 1, 2019. The PEI government is working on a new sustainable development strategy for plastic waste management and also considering developing EPR for packaging products.

New Brunswick (NB): The province of NB is not considering any ban on single-use plastic at the moment. NB continues to have the lowest number of legislated EPR programs in the country.

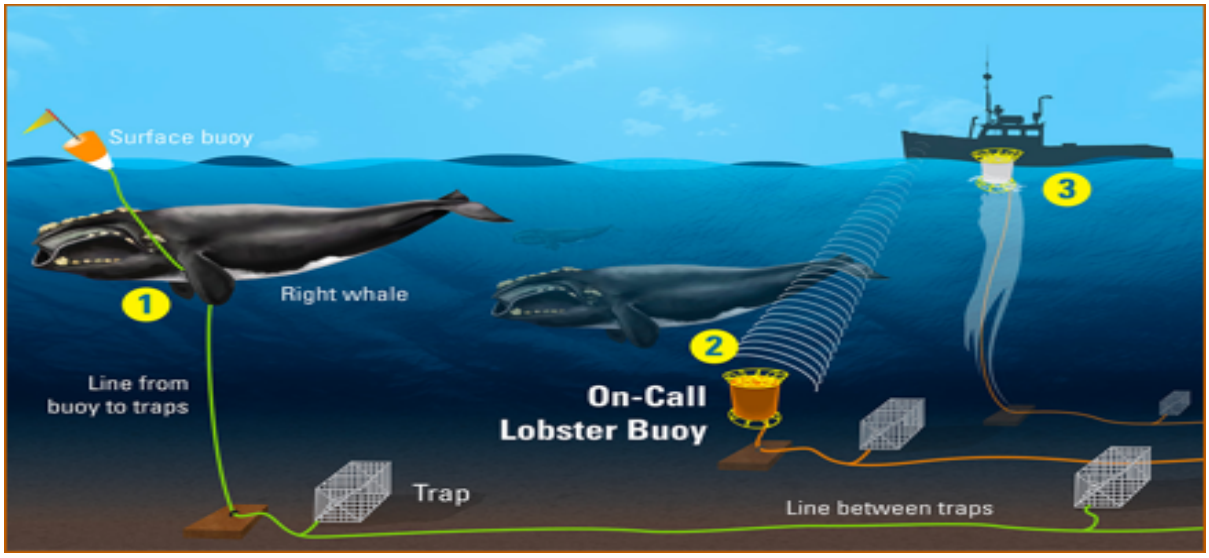

Figure 10: Ropeless Fishing Gear System; Source: Oceanus Magazine, Whale-safe fishing

Nova Scotia (NS): NS is the only province with a dedicated solid waste management strategy since 1995 that includes the development of EPR Action Plan. However, there has been little or no progress made on the policy since then. The province follows a linear economy for waste disposal, but there is a landfill ban on plastic film, which was temporarily lifted after China refused to import plastic from North American markets (Government of Nova Scotia, 2018).

Nova Scotia recently took an innovative approach to clear fishing gear. Two Nova Scotian businesses Ashored Innovations Ltd. And Goodwood Plastics received separate grants from Fisheries and Oceans Canada for their innovative solution to get rid of the Ghost gears by designing a low-cost ropeless fishing system (figure 10) and gear tracking system (The Government of Canada, 2019e).

Newfoundland (NL): NL became the second province to bring a province-wide ban on single-use plastic on retail bags. The province is working towards developing EPR for packaging products.

Yukon (YT): YT does not have a territory-wide ban on single-use plastic, but it endorses territory-wide fee on plastic bags.

Northwestern Territories (NWT): Under *Waste Reduction Recovery Tax* NWT has *Single-Use Retail Bag Regulation* where the government charges 25 cents tax on retail bags. Waste management disposal in NT depends on the linear economy with no EPR policies.

Nunavut (NU): Single-use plastic bags have been banned from Iqaluit stores. The waste management disposal in NU depends on the linear economy with no EPR policies.

Table 3 summarizes the strategies adopted by the federal, provincial and territorial governments to handle land as well as aquatic plastic waste and the actions taken so far by each jurisdiction. Table 3 summarizes the strategies adopted by the federal, provincial and territorial governments to handle land as well as aquatic plastic waste and the actions taken so far by each jurisdiction. These policies, as mentioned above, are split into four classifications in each province and territory, such as waste management, plastic ban, EPR and circular or linear economy, helping to reduce microplastic pollution. Apart from these four strategies, there are several local shoreline cleanup programs taken up by different jurisdictions. Many non-governmental organizations such as the Great Canadian Shoreline Cleanup (OCEANWISE & WWF) are building a community of shoreline cleanup by involving volunteer from various municipalities to join their programs. In 2019, volunteers coordinated 180 cleanups and collected 3,398 kg of litter from the 670 km of the Canadian Shoreline (Great Canadian Shoreline Cleanup, 2019).

Table 3: Federal and provincial strategies to handle plastic waste Source: Adapted from various sources, Government of Canada, CCME (State of Waste management in Canada) Government of BC, AB, SK, MB, ON, QC, PEI, NB, NS, NL, YT, NWT & NU.

Jurisdiction	Category	Action
Federal	Waste management Strategy	Greening Government Strategy, Oceans plastic Charter, Global Ghost Gear Initiative, Strategy on Zero Plastic Waste
	Plastic Ban	Yet to introduce policies to bring a nationwide ban on single-use plastic
	EPR	Failed to implement EPR goals in phase 2
	Circular Economy/Linear Economy	Domestically Government of Canada is collaborating with provincial and territorial governments through CCME to move forward to circular economy approach
BC	Waste management Strategy	Environmental Management Act (2003), Recycling Regulation (2004, 2012)
	Plastic Ban	Although many municipalities have individually banned single-use plastic but municipal leaders call for a provincial ban on single-use plastic. Vancouver introduced single-use plastic ban in 2018 but not implemented yet. Victoria started charging 15 cents levy for plastic bags but no complete ban on plastic.
	EPR	Only jurisdiction that has implemented EPR successfully so far
	Circular Economy/Linear Economy	There is 5R (reduce, reuse, recycle, recovery and residual management) hierarchy that supports circular economy.
AB	Waste management Strategy	*Too good to Waste* strategy identifies opportunities, outcomes and strategies to help the province move forward with innovative waste management programs.
	Plastic Ban	Regional municipalities like wood Buffalo and Wetaskiwin have banned single-use plastic bags
	EPR	Does not have any EPR programs
	Circular Economy/Linear Economy	-
SK	Waste management Strategy	The Municipal Refuse Management Regulation (MRMR) and Solid Waste Management Strategy (2005)
	Plastic Ban	Not considering any ban at the moment
	EPR	Delivers EPR programs with only partial approaches
	Circular Economy/Linear Economy	Linear Economy
MB	Waste management Strategy	Landfill operations regulated under The Environment Act and the Waste Disposal Ground Regulation and Waste Reduction and Prevention Act (WRAP, 1990).
	Plastic Ban	Not considering a province wide ban at the moment however a 3-cent levy is being charged on plastic bags although Leaf Rapids became the first community to ban plastic bags.
	EPR	Continuing focus on EPR
	Circular Economy/Linear Economy	Linear Economy
ON	Waste management Strategy	Environmental Protection Act (1990); Waste reduction Act
	Plastic Ban	Aiming for single-use plastic ban by adopting waste diversion strategy. Sioux Lookout and Greenstone banned plastic but later on rescinded the decision due to public pressure
	EPR	The introduction of new Waste Reduction Act promotes more targeted EPR programs but not implemented completely
	Circular Economy/Linear Economy	Supports Waste-free strategy for circular economy
QC	Waste management Strategy	Environmental Quality Act
	Plastic Ban	Montreal officially banned single-use plastic bags but still pending due to lawsuits from retailers and plastic industry. Huntington ban plastic bags including flyers in the newspapers
	EPR	The waste reduction policy includes directions for EPR
	Circular Economy/Linear Economy	In transition for circular economy
PEI	Waste management Strategy	Environment Protection Act (1988); Materials Regulations Act (2009); the Environment Tax Act (1982) that imposes levy on tires (1991). The government is working on a new Sustainable Development Strategy and waste management will be an element of this Strategy.
	Plastic Ban	First province to ban single-use plastic bags under Plastic Bag Reduction Act July 1, 2019
	EPR	In consideration for developing EPR for packaging and printing paper
	Circular Economy/Linear Economy	-
NB	Waste management Strategy	Clean Environment Act (1996)
	Plastic Ban	Not considering a ban
	EPR	Continues to have lowest number of legislated EPR programs in the country
	Circular Economy/Linear Economy	-
NS	Waste management Strategy	Environmental Act (1994-95) Only jurisdiction to implement dedicated solid waste management strategy in 1995 that includes the development of an EPR Action Plan. However plastic films are landfilled in the province.
	Plastic Ban	Not considering a ban on plastic bags
	EPR	There has been little or no progress on EPR in Nova Scotia
	Circular Economy/Linear Economy	Linear Economy
NL	Waste management Strategy	Environmental Protection Act 2002. In 2002 the province released a Provincial Solid Waste Management Strategy which outlines specific goals which were revised in 2007 with a provincial government commitment of $200 million and a specific implementation plan to modernize waste management across the province.
	Plastic Ban	Becomes second province to ban single-use plastic bags (retails bags)
	EPR	Working towards developing an EPR for the management of packaging and printing paper as a long-term strategy.
	Circular Economy/Linear Economy	Linear Economy
YT	Waste management Strategy	Environmental Act 2002; Yukon's Solid Waste Action Plan 2010 called for number of waste management activities and permits issued under regulations set standards for dumping and landfills.
	Plastic Ban	Endorses territory-wide plastic bag fee
	EPR	Does not include EPR
	Circular Economy/Linear Economy	Linear Economy
NT	Waste management Strategy	Waste Reduction Recovery Act (WRRA)
	Plastic Ban	Under *Single-Use Retail Bag Regulation* of WRRA the province charges 25 cents tax on plastic bags
	EPR	Does not include EPR
	Circular Economy/Linear Economy	Linear Economy
NU	Waste management Strategy	Environmental Protection Act, (2011) focussing on protection, preservation and enhancement of environment. Nunavut does not yet have legislation that pertains directly to solid waste management, nor is there a specific strategy for solid waste management.
	Plastic Ban	Single-use plastic bags have been banned from Iqualuit stores
	EPR	Does not include EPR
	Circular Economy/Linear Economy	Linear Economy

CHAPTER 5: NEED FOR REGULATION-INTERNATIONAL EFFORTS

Many countries around the world are in agreement that plastic pollution is a significant crisis that our world is facing currently. This plastic crisis is acting as an obstacle to the adoption of the SDGs set out in the UN Agenda 2030 which highlight water quality and implementation of 3Rs of waste management such as, reduction, recycling and reuse as one their goals (Rodic, 2017). Signed in 1973, the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) was designed, amongst other things, to prevent the disposal of plastics to the sea, but the problem of marine debris has worsened, likely because the marine debris problem is related to poor waste management on land (Jambeck et al., 2015). World Economic Forum (WEF) and World Bank are the two agencies which are working towards the programs to address the plastic waste management plans. Pollution Management and Environmental Health (PMEH) of the World Bank is one such program (Brennholt, 2018b). There is a clear need for advanced research into the effects of plastic debris, especially for microplastics in the natural terrestrial habitats, on the agricultural lands and in freshwaters (Thompson et al. 2009).

Most recently international plastic waste reduction instruments have been created using the Honolulu Strategy, a thorough and international leadership framework to mitigate the effects of marine debris (Xanthos et al. 2017 & Walker et al. 2014). This strategy has been implemented worldwide as a framework for the prevention and management of marine debris, including plastic waste (S.Pettipas et al. 2016). Strategies include market-based instruments (e.g., single-use plastic bag levies) to decrease waste and legislation to decrease marine

debris (e.g., bans on single-use plastic, microbeads or plastic bags) (Xanthos et al. 2017). Based on these strategies, the EU released a revised model of Plastic Directive in 2019, followed by a complete ban on single-use plastic in march 2019. This chapter explores the various regulatory models adopted by the EU to regulate microplastic compared to the actions taken by the Canadian government in similar ways. An effort has been made to do a comparative jurisdictional study to comprehend the necessity for new regulation. This chapter is divided into themes such as

- single-use plastic,
- circular economy,
- labelling,
- recycling,
- EPR and
- waste management

which is further subdivided into sections to explain the measures that the EU has taken or that are ongoing as compared to the current status of these measures from a Canadian point of view. The idea behind the study is to assist in filling the gap for Canada's policymakers, where action needs to be taken.

a. Single-Use Plastic

European Model

In Europe, regulatory actions have already been taken under different jurisdictions to control the release of plastic waste into the environment. Many countries in Europe have started moving towards better strategies for recycling and legislation to ban landfills. The EU Commission is targeting 10 items identified under EU Directive these include a ban on plastic straws, cups, plates and cotton buds. Other countries like Belgium, Italy, France, Morocco, Bangladesh and Malaysia have set an example by bringing a total ban on plastic bags (Figure

11). Several Municipalities in Canada are considering to propose a complete on ban single-use plastic such as plastic bags, straws, cups and bottles.

Action: EU voted to ban single-use plastic in March 2019 under European Plastic Directive.

Canadian Model

Although Canada has shown leadership by promoting Oceans Plastic Charter during G7 meeting in 2018 and recently announcing a federal ban on single-use plastic, this announcement came four years after the release of the action plan by Council of Canadian Ministers of Environment (CCME) on Zero Waste Strategy.

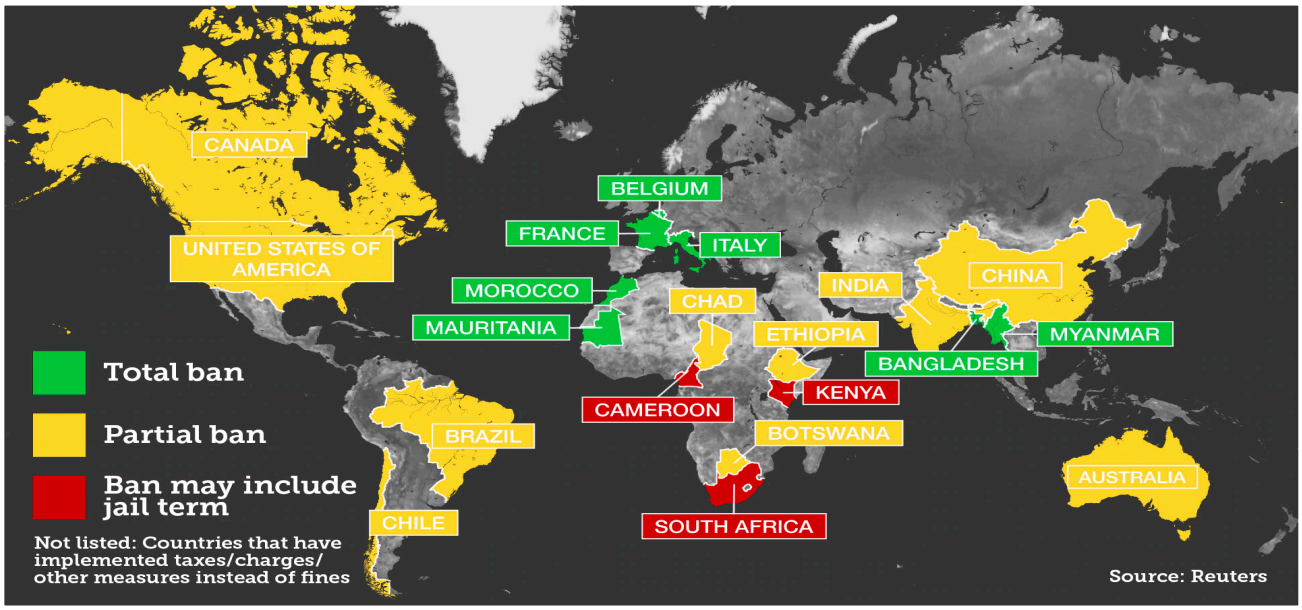

Figure 11: Countries with total or partial ban on plastic; Source SBS News,2017*https://www.sbs.com.au/news/taxes-fines-and-jail-time-the-strictest-plastic-bag-laws-around-the-world*

It is encouraging for others to follow suit. Many big companies like Haagen Dazs, Starbucks, Nestle' have pledged to go plastic-free by 2025. But banning plastic bags and other plastic products at an individual level will not solve the macro issue of (micro)plastic. Action from the federal government is much needed to achieve goals set for a sustainable future.

Action: Canada announced a ban on single-use plastic by 2021 on 10th June 2019.

b. Circular Economy

European Model

The European Commission is committed to protecting its waters and the environment. The microplastic regulation has already been considered in the EU (European Union) through several directives, guidelines, agreements, for example, REACH (REGISTRATION, EVALUATION, AUTHORISATION AND RESTRICTION OF CHEMICALS) (Brennholt, 2018b) and the circular economy directive. The Commission adopted a comprehensive plan on the circular economy in December 2015 (European Commission, 2019). A circular economy for plastic is identified as the main priority. The Action plan commits to preparing a strategy addressing the challenges related to marine litter and will contribute towards achieving the SDGs. The EU Strategy for plastics in the circular economy, in context with the Circular Economy Packaging, was built upon four pillars; (European Commission, 2019).

- ***Improve product design***-Improving the economics and quality of plastics recycling, with actions related to improving product design, boosting recycled content and improving separate collection of plastic waste,
- ***Actions to curb microplastic pollution-***Curbing plastic waste and littering, with actions to reduce single-use plastics, tackle sea-based sources of marine litter, monitor and curb marine litter more effectively, actions on compostable and biodegradable plastics and actions to curb microplastics pollution,
- ***Investment and funding of innovative solutions***-Driving investment and innovation towards circular solutions, with actions to promote investment and innovation in the value chain,
- ***Global actions-***Harnessing global action, with actions at a bilateral and multilateral level as well as actions related to international trade.

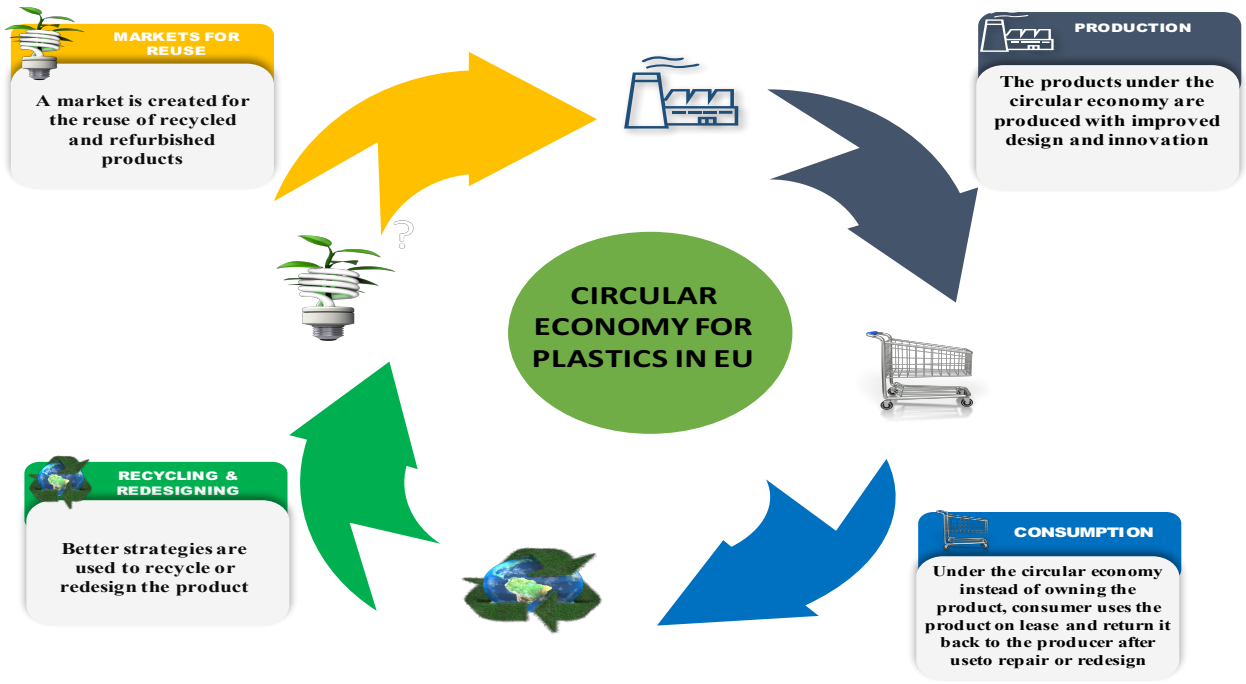

Figure 12: The Circular Economy Model for Plastics by EU Commission Source: Adapted from EU Commission, 2018

Listed below are some of the highlights from the action plan of Circular Economy to curb plastic pollution; (European Commission, 2019).

- ***Single-Use Plastic-*** As a part of the implementation action, the commission has proposed to identify and target 10 single-use plastic items commonly found on the beaches and seas as well as of the lost and abandoned fishing gear with the agreement from co-legislators.
- ***Waste Delivery from ships-*** According to the new rules proposed in December 2018, the port reception facilities should make sure that the waste (with particular focus on reducing marine plastic litter) is delivered to the adequate facilities onshore, instead of being discharged at sea.
- ***Stakeholders Involvement-*** The Commission organised a pledging campaign, calling on industrial stakeholders to make voluntary pledges with a target of ensuring that 10 million tonnes of plastics are being recycled into new products by 2025. The *Circular Plastics Alliance* is established to help achieve the objective and improve the quality and economics of recycling of plastic in Europe by facilitating the next steps of supply and demand chains of businesses.

The EU Commission presented a progress report on the implementation of the Circular Economy Action Plan on 4th March 2019 to the European Parliament, at Brussels. The action plan is adopted to expedited a shift to the circular economy in terms of single-use plastics. As per the report, the following measures will be adopted as legislation under a single-use plastic strategy of the circular economy action plan to address the issue of microplastic pollution (European Commission, 2019).

- EU has approved to adopt a complete ban on *single-use plastic* such as straws, plates, cutlery, stirrers, cotton bud sticks, cups and all products made from polystyrene by 2021 with the agreement of 560 Members of European Parliament (MEPs)
- Specific *labelling system* should be adopted for the packaging containers for improved recycling practices.
- Enhanced *EPR strategy* to recover litter, being also applied to cigarette butts and fishing gears.
- A target to incorporate 25% of recycled plastic in PET bottles as from 2025 and 30% in all plastic bottles as from 2030, as well as a 90% separate collection target for plastic bottles by 2029 (77% bottles by 2025) and the introduction of design requirements to connect caps to bottles.

Action: The commission reported the complete execution of the action plan in March 2019 that was originally adopted in December 2015 its EU plastic directive progress report.

Canadian Model

In Canada, the current flow of material and waste disposal in Canada is Linear where the vast majority of products after usage end up either into the landfills or into the incinerators. Similar to EU, the CCME in Canada released its Action plan for the circular economy as "STRATEGY ON ZERO PLASTIC WASTE" in 2018 based on international commitments such as "THE OCEAN PLASTIC CHARTER."

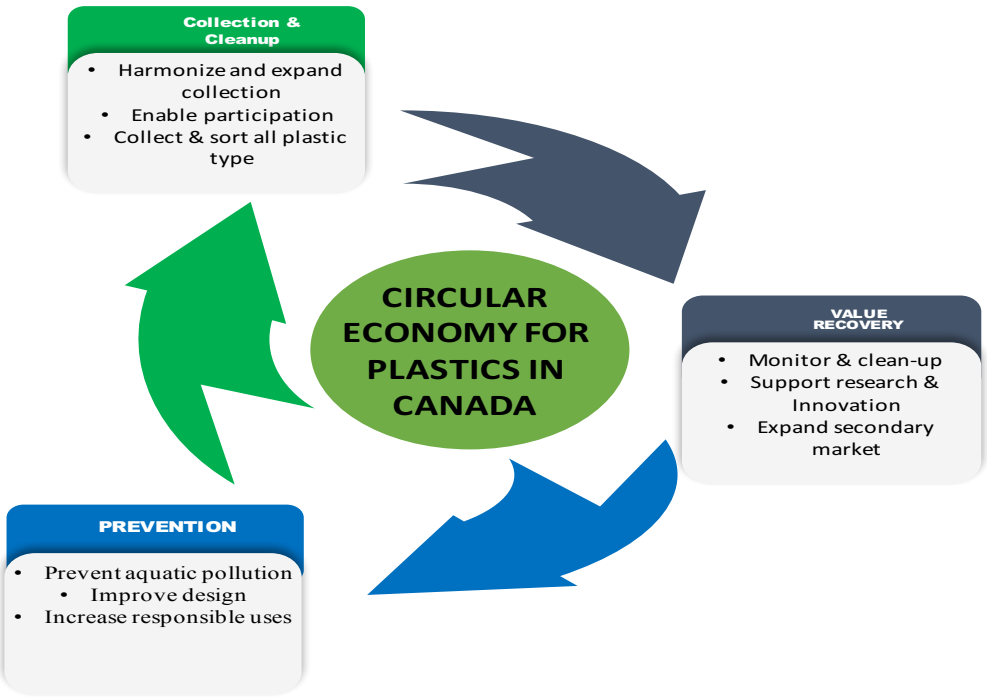

Figure 13: The Circular Economy Model in Canada; Source: Adapted from CCME, 2018

The circular economy model presented in the action plan by CCME, as shown in figure 13, focusses on (CCME, 2018).

- ***Prevention-*** This includes prevention of plastic waste entering the aquatic ecosystems, improved designs for longevity and reparability and increased responsible uses by decreasing the demand for disposable products.
- ***Collection and Cleanup-*** Collection of all plastic products that include cleanup also, so they are rerouted into the economy.
- ***Recovery-*** This includes, increased monitoring and cleanup for plastic products, support for research and innovation and creating marking for the recycled products.

Action: Currently, Canada's transition to the circular economy is happening at a slow rate as compared to Europe. As compared to the circular economy model in the EU, Canada is missing one big step of creating a market for recyclable goods. Without the market for the refurbished good, the products would not circulate in a closed loop.

c. EPR

European Model

With the introduction of the Circular Economy, the European Commission aimed to promote EPR, that can last longer, to develop more sustainable products in compliance with the SDGs with the help of innovative designs. This EPR strategy will help in achieving higher recycling rates hence reduce plastic waste generation. According to the Circular Economy progress report, these EPR schemes are now well established for the packaging products where producer takes responsibility for its products. With newly introduced legislation on waste by EU in May 2018, EPR has become mandatory for the packaging products. The EPR also includes the litter cleanup cost. The measure for fishing gear, which accounts for about 27% (11,000 tonnes per year) of marine litter, is an EPR scheme for gear containing plastic, to ensure that the cost of managing waste plastic fishing gear, is covered by the producers of plastic fishing gear (European Commission, 2019).

Action: EPR schemes are well established for packaging where producer agreed to contribute. With newly adopted legislation on Waste by EU in July 2018, EPR became mandatory for all packaging products.

Canadian Model

EPR has been there in Canada since 2009 and has been mentioned as a strategy in CCME document but yet hasn't been implemented fully in Canada (Prof. Buonsante, Personal Communication, 2019). In the Canadian action plan for the circular economy by CCME, EPR is described as the foundation towards the natural transition from the current linear economy for plastic waste management to the circular economy. EPR system is running successfully in BC while in Quebec, EPR is implemented as the producer pays the

amount for waste management to the system (Prof. Buonsante, Personal Communication, 2019).

Action: The EPR stewardship for packaging, municipalities across Canada operate individual recycling system with little or no coordination with other municipalities and no connection to the producers whose packaging they manage. Hence, each municipality is left to address the changing packaging mix and commodity market realities within their system.

d. Recycling

European Model

A revised packaging directive has been adopted in European Union on 30th May 2018 that focusses on recycling 70% of packaging by 2030 and 65% of municipal waste by 2035 this also includes a reduction of a landfill to maximum of 10% of municipal waste by 2035 (European Commission, 2019). A separate collection directive has been issued for hazardous household waste (by end 2022), bio-waste (by end 2023) and textiles (by end 2025) (European Commission, 2019). This separate collection directive will possibly help to reduce the release of microplastics in the environment.

Action: The directive (2018/852) for plastic packaging recycling set at 50% by weight. The recycling rates had increased from 43.7% to 46.4 in 2017, and the volume of landfilled municipal waste has decreased by 20.6% between 2013 and 2017 (European Commission, 2019). Minimum targets for plastic wastes recycling set at 50% by Dec 2025 and 55% by 2030 (SAM, 2019).

Canadian Model

The per capita waste generation in Canada depends upon the population of the area (Statistics Canada, 2016). The total amount of plastic waste from residential and non-

residential sources has increased from 144,181 tonnes in 2002 to 318,550 tonnes in 2012 as per Statistics Canada, as shown in figure 14 (Statistic Canada, 2016). Canada's recycling ranking is abysmal in comparison to other countries around the world. Canada recycles only 11% of the plastic waste rest of its waste either land up into the incinerators or dumped into the landfills. The rate of plastic waste diversions in Canada shows not much of change since 2008 (296,797) to 2016 (382,097) (figure 15). Many municipalities in Canada still depend on landfills and incinerators for the disposal of the vast majority of their plastic waste.

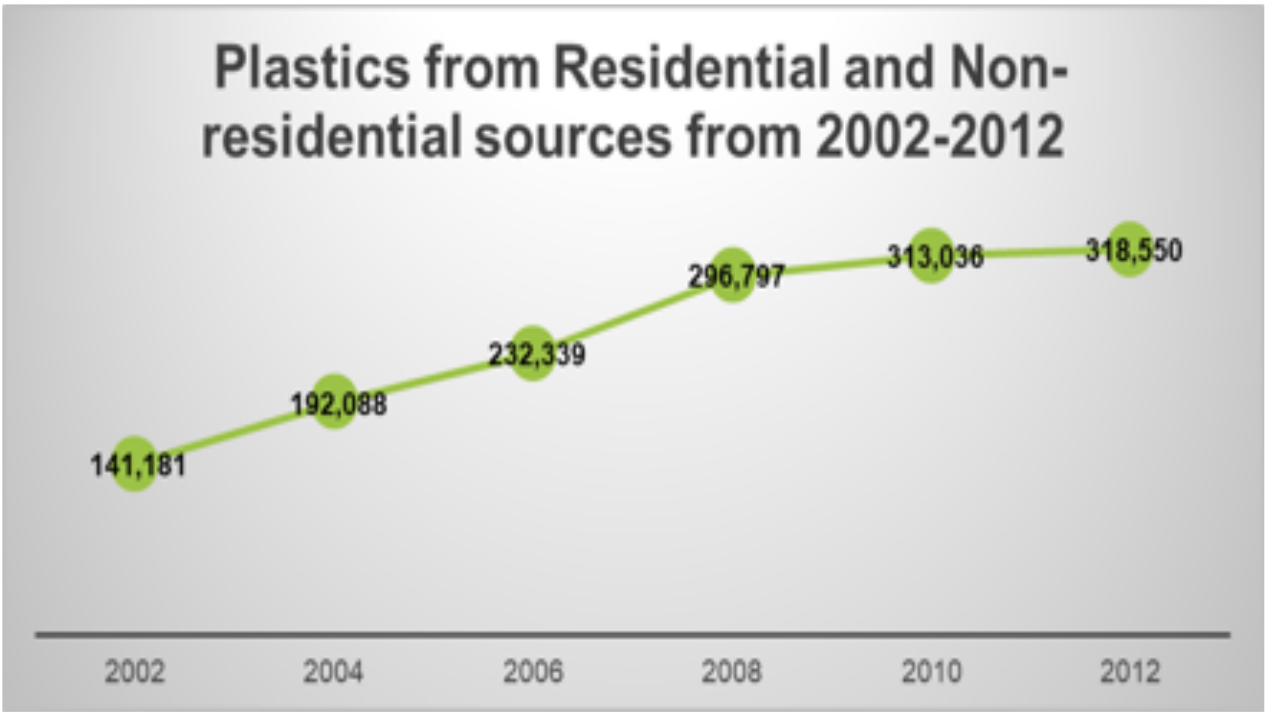

Figure 14: Plastic wastes generated in tonnes from Residential and Non-residential sources from 2002-2012; Source: Adapted from Statistics Canada, 2015

Much of the plastic waste generated in the country is exported to China. However, starting 1st January 2018, China has refused to take in any recyclable material from the developed countries due to increased levels of contamination and lack of regulations for the imported plastic waste (Stanislaus, 2018). The Chinese refusal to import plastic litter for recycling has put a burden on the landfills around the country. The export of plastic waste to

China has proven to be the easiest and the most effective way of getting rid of the unwanted plastics.

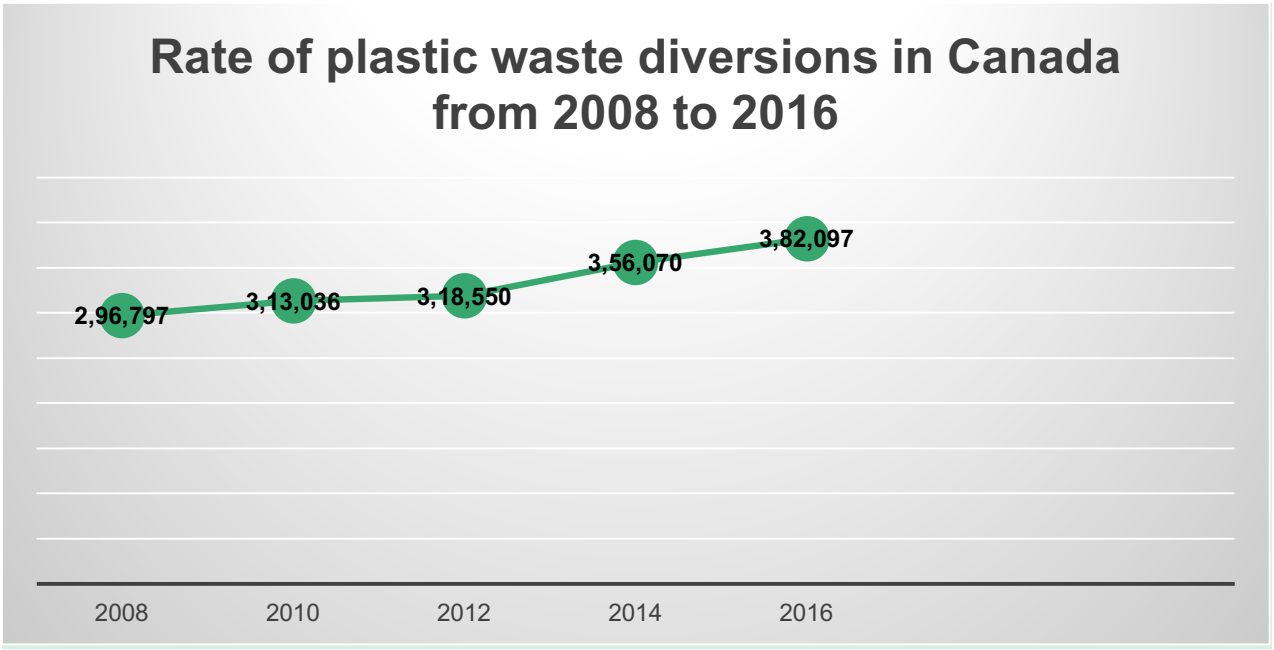

Figure 15: Rate of plastic waste diverted from 2008 to 2018 in Canada; Source Adapted from Statistics Canada, 2019https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810003401

Following the action from China, many other countries like the Philippines and Malaysia have entered into 'trash wars' with Canada. Now, the countries like USA, Canada, UK and Australia are being forced to look for more innovative and sustainable solutions to the plastic waste piling up in their facilities.

Action: It has been noted that only 9% of the total plastic waste generated each is being recycled in Canada (Geyer et al. 2017). Rest all either lands up in landfills or in the incinerators. Prof. Buonsante commented that the main problem with recycling is the sorting of waste because it is expensive and takes time; therefore we send our recyclable products to developing countries.

e. Microplastics Regulation

European Model

Under EU microplastics regulation, measures have been taken to monitor and reduce marine litter more efficiently harmonized with other techniques. The EU Microplastic Plastic Directive states the reformulation of pre-production plastics and related delivery processes to decrease the likelihood of spills and accidents considerably. Efforts are being made to develop policy alternatives for reducing the unintentional release of microplastics from tires, textiles and paints (European Commission, 2019). The EU Commission also has a Waste Water Treatment Directive that assesses the effectiveness of the treatment plants for capturing microplastics.

Action: United Nations Environment Assembly on Dec 2017 adopted a resolution on marine litter and microplastics. The EU Commission also has a Waste Water Treatment Directive that assesses the effectiveness of the treatment plants for capturing microplastics. A certificate scheme under Industrial Emission Directive has been developed to reduce the marine spillage of plastic pellets.

Canadian Model

In Canada, not much has been done to tackle the issue of microplastic pollution except for the regulation on the intentional use of microbeads in personal care products. The CCME reports on zero waste policy indicate that the government is working with the sector in addressing microplastics sources, but no action has been taken so far. Useful capture devices and shoreline clean-up programs are suggested as a remediation effort for the plastic litter before it gets broken down into smaller fragments (CCME, 2018). CEPA is the only way the federal government can control the microplastics pollution as it is a very flexible tool and can bring a positive change to the society (Prof. Buonsante, Personal Communication, 2019).

Action: No regulation to control microplastics other than the microbeads. The federal government imposed a ban on microbeads, i.e. July 2018, but it was too limited to personal care products only it does not cover the release of microplastics from other sources such as tires, paints or wastewater treatment plants.

f. Labelling

European Model

European Commission Plastic Directive introduced the labelling system differentiating 'compostable' and 'biodegradable' plastic to ensure consumers are provided with clear information. The Commission has developed harmonized rules on defining and labelling. A lifecycle assessment is conducted to identify conditions where their use is beneficial and criteria for such an application (European Commission, 2019). REACH regulations are being considered to restrict the use of oxo-plastics (European Commission, 2019).

Action: The Commission has started work to restrict alternative materials claiming to be biodegradable 'Oxo-degradable plastics' in EU. The EU has completely banned oxo-plastics which were being sold as biodegradable for many years (Prof. Buonsante, Personal Communication, 2019). A ban has been imposed on them along with single-use plastic in March 2019. A harmonised labelling system is in place since 2018 to differentiate between compostable and biodegradable plastics.

Canadian Model

In Canada, the CCME Action Plan (2018) states that enhancing norms such as improving labelling or recycling demands for material in consumer products plays a role in helping reuse and recycling plastics in the best possible way, but not much has been accomplished on this. There is no uniform labelling of chemicals or compostable products available to consumers to make recyclability of the products easier.

Action: There is a lot of problems around composting, and the products cannot always be recycled. Canada has no clear labelling scheme to facilitate the sorting portion of recycling. There is also little regulation or standardization in Canada as to what composting means and most composting products are not accepted in municipal installations in Canada (Prof. Buonsante, Personal Communication, 2019). As part of their "microplastic strategy," the European Commission has already started to label their products as compostable and non-compostable to limit alternative materials claiming to be compostable. Canada must also take such steps to enhance its recycling strategies.

g. Water Pollution Measures

European Model

Maintaining water quality is most important, and under the EU Water Framework Directive and Marine Strategy Framework Directive are the two principal regulations that were established to protect European freshwater and marine waters (European Commission, 2019). Out of these two Marine Strategy Framework Directive (MSFD) is the only legal EU framework that helps to tackle plastic litter and microplastic pollution (European Commission, 2019).

Action: The Commission is ongoing evaluation of the MSFD and UWWTD to be completed in 2019 according to the plastic strategy (SAM, 2019).

Canadian Model

In Canada, regulations have been developed under the Fisheries Act to regulate the flow of untreated wastewater to freshwater and countrywide municipal wastewater effluent. The federal government is investing in science-based programs to understand the source of macro and microplastic debris in the aquatic environment (European Commission, 2019).

Action: The Canadian Government is investing in science-based programs to understand the source of microplastics into the environment. A little progress has been made on this.

h. Additional regulation

European Model

Ecolabel and Green Public Procurement criteria have been developed to improve the recyclability of plastics. Under Horizon 2020 EU finances research and innovation projects on better identification of contaminants and decontamination of plastic waste (European, Commission, 2019). Better and more harmonized separate collection, sorting of plastic waste were introduced for increased recyclability of the plastic waste. The Commission strongly supports European parliament and the council to amend waste rules to ensure better implementation of a collection of plastics separately. EU has taken steps by setting requirements for member states to adopt measures to cut the consumption of plastic bags and to monitor and reduce marine litter.

Action: Ecolabel and Green Public Procurement are running successfully to promote reusable items and packaging. ORPLAST, a French public procurement system is an excellent example to achieve a great deal through economic benefits (European Commission, 2019).

Canadian Model

The Government of Canada announced a Greening Government Strategy in September 2017 under which they have committed to diverting 75% of the plastic waste from general operations by 2030 (The Government of Canada, 2018d). Canada launched '*Oceans Plastic Charter*' at G7 meeting to endorse a ban on single-use plastic. The federal government, in

collaboration with CCME, launched an action plan of the 'circular economy for plastics.' Canada joined 'Global Ghost Initiative' to get rid of the abandoned fishing gears in the ocean.

Actions: The Standing Committee's latest 2019 progress report on 'Greening Government Strategy' states that since its launch in 2017, the policy has contributed a lot towards reducing GHGs, but also believes that a lot needs to be accomplished in other sectors (Standing Committee, 2019). Recently, Canada has made progress in banning single-use plastic, but, it is moving at a slower rate than the EU. Canada's fisheries department says that although some regional efforts are being made no national policy exists to remove gears from the Canadian waters.

i. Waste management

European Model

The Commission has established waste management guidelines, that includes more specific guidelines to step up a separate collection, targeting investment in recycling capacity and avoid infrastructural overcapacity for processing mixed waste (e.g. incineration) (European Commission, 2019). Invest in waste collection/management infrastructure and wastewater treatment facilities to prevent leakage of plastic debris into the environment. There has been some improvement in meeting the EU waste management requirement; however, waste treatment commitments are still not fully satisfied (European Commission, 2019a). The Commission further stated that the use landfill should be exceptional rather than a norm and the member states must ensure by 2035 no more than 10% of the waste is landfilled (European Commission, 2019).

Action: There has been some improvement in meeting the EU requirement for waste management; however, waste treatment obligations are still not fully satisfied (European Commission, 2019). A revised directive entered into force on a landfill in 2018 and must be transposed into regulation by 2020 (European Commission, 2019).

Canadian Model

Canada announced to invest $100 million to support developing countries to develop and implement sound waste management practices along with $12 million for domestic plastic innovation challenges. Canada is in a transition towards a Circular economy for the plastic; however, no policies have been entirely implemented at the federal level. The CCME report mentions that there are specific well-established waste management programs, but the system needs to be improved to move away from the linear economy to a circular economy. Currently, more than 89% of plastic waste is landfilled and incinerated in Canada (CCME, 2018).

Action: The waste management practices in Canada are ineffective with a large number of plastics are landfilled or incinerated and may be discharged to the environment through litter and illegal dumping.

j. Economic benefits

European Model

The EU CE directive is committed to developing innovative business models, reverse logistics for sustainability to minimize plastic waste at its source while achieving economic and social benefits. The Commission stresses that by bringing a change in production and designs will help create more jobs. Rethinking the functioning of complex value chain requires the cooperation from different stakeholders, recyclers and retailers. With the transition to the circular economy, there has been an increase in investment, jobs and innovation sector. It has been reported that the trade within the EU has increased for paper, plastic, aluminum and copper between 2004 to 2016, helping boost the economy (European Commission, 2019).

Action: The transition to a circular economy improves investment, stimulates innovative ideas and increases employment. The trade within the EU has increased for paper, plastic, aluminum and copper between 2004 to 2016, helping boost the economy.

Canadian Model

The Canadian government is investing $6 million for innovative private-public plastic initiatives through WEF. The federal government is redefining plastic waste management to gain more economic benefits, such as creating more jobs by promoting innovation and redesign.

Action: Not enough focus on innovation because of less incentive provided. Low oil and gas prices make renewables and recyclable products uncompetitive for setting markets of recyclables.

The above comparison demonstrates where Canada stands in terms of progress compared to the EU to mitigate the effect of microplastic pollution. As far as laws and their execution are concerned, the progress achieved by the European Union is much faster than Canada. Canada has set targets for the future ban on single-use plastics, but little has been done to implement the strategies. Banning single-use plastic nationwide would assist control the adverse effects of plastic pollution and thereby prevent bioaccumulation of microplastic in the oceans, but there is a need for more stringent regulation to handle microplastic pollution just like microbeads.

The EU has already moved forward with the ban after the introduction of their plastic directive in 2018. According to CCME, Canada has plans to move to a circular economy by

pursuing a zero-plastic waste strategy. Canada wants to move towards a circular economy as much as the EU, but there is a risk of shifting towards a circular economy (CE) because in Canada CE believes of recycling over and over while it should be more like reducing, reusing and refurbishing (Prof. Buonsante, Personal Communication, 2019). While the Ministry of the Environment and Climate Change recognizes the need to mitigate the effect of microplastics and recognizes this as a domestic issue, no further action has been taken by the federal government to introduce microplastics laws other than the ban on microbeads in 2018. At this point, it becomes apparent that although marine ecosystems are in the center of interest, freshwater systems cannot be neglected (Brennholt et al. 2017a). Prof. Buonsante believes that the transition from the linear economy to the circular economy will be time-consuming and work differently, as we collect 90% of the plastic bottles commonly found in the environment. But, according to him, there are many other products other than bottles such as plastic wrappers, where the scheme may not work. Hence, we need to rethink our entire economy. A substantial disparity was discovered in the theoretical aspects and the execution of strategies in Canada compared to their European counterpart.

Table (4) below summarises the policies adopted by both the EU and the Canadian government and the action taken so far. It explains the policies models developed by both jurisdictions to curb microplastic pollution. This was done with the help of extensive literature review of European Union Commission Plastic Directive, 2019, Microplastic Pollution, Policy Context, 2018 and CCME, Zero Plastic Waste, 2018 along with the inputs from the personal communication with Prof. Buonsante, 2019. In total ten, relevant EU policies were compared with the Canadian policies to understand their current status in terms of processing, implementation and the action taken so far.

Table 4: A comparative study of (micro)plastics regulations in European Union Vs Canada

Source: European Union Commission, 2019, SAM 2018, CCME, 2018 & Personal Communication with Prof. Buonsante.

POLICY MEASURES	EUROPEAN UNION	ACTION	CANADA	ACTION
SINGLE-USE PLASTIC	Identify and target 10 single-use plastic products commonly found on the beaches as well as the lost fishing gear	EU approved to adopt a complete ban on single-use plastic on products such as straws, cutlery and stirrers and all other packaging products made from polystyrene	Canadian government took first steps under Oceans Plastic Charger at G7 to propose a complete ban on single-use plastic	The federal government has recently announced a ban on single-use plastic products by 2021 but what would be regulated would be finalized after risk management
CIRCULAR ECONOMY	EU adopted an action plan in December 20115 for plastics based on CE that focuses on closing the loop and ensuring sustainable development by 2030. Promote innovation and reuse	The council officially reported the complete execution of the action plan in March 2019	CCME introduced an action plan for Zero Plastic Strategy where the main focus was on Prevention, Collection and Recovery	Canada is recycling less than 9% of its plastic waste. Its current approach is linear. Canada would like to move towards circular economy but it really needs to embed reduce, reuse and repurpose into its strategy. Its transition to the circular economy from linear is at a very slow rate.
EPR	The Commission aimed to promote EPR to develop more sustainable plastic products by promoting innovative designs to improve the way plastics and plastics products are produced and design to achieve higher recycling rates.	EPR schemes are well established for packaging where producer agreed to contribute. With newly adopted legislation on Waste by EU in July 2018, EPR became mandatory for all packaging products.	EPR serves as a foundation towards easy transition from linear economy to circular economy in the CCME action plan for Zero Plastic strategy.	Under EPR stewardship for packaging, municipalities across Canada operate individual recycling system with little or no coordination with other municipalities and no connection to the producers whose packaging they manage. Hence, each municipality is left to address the changing packaging mix and commodity market realities within their own system.
RECYCLING	The 2015 action plan for plastic strategy proposed recycling targets as all plastic should be recyclable by 2030. Reward the uptake of recycled plastics and favour reuse and recycling over landfilling and incineration.	The directive (2018/852) for plastic packaging recycling set at 50% by weight. The recycling rates have increased from 43.7% to 46.4 in 2017 and the volume of landfilled municipal waste has decreased by 20.6% between 2013	Integrating reuse and recycling into the design of plastic products to reduce cost and bring back the materials into the economy.	Currently a significant portion of plastic that is recycled is 'down-cycled' i.e. after one recycling no further recycling can be done hence the product ultimately gets dumped to the landfills and discarded to the environment. The waste diversion rates of

		and 2017 (European Commission, 2019).		plastics have increased from 296,797 in 2008 to 382,097 in 2016 (Statistics Canada, 2019).
MICROPLASTICS	Actions have been ongoing to examine the policy options for reducing unintentional release of microplastics from tires, textiles and paints (e.g. including minimum requirement for tire design, abrasion and durability and information requirement including labelling, methods to assess microplastics losses from textiles and tires, combined with details including possibly labelling, targeted research and development funding) (European Commission, 2018). The reformulation of pre-production plastics and associated delivery mechanisms to significantly reduce the risk of spills and accidents.	A resolution on marine litter and microplastics was adopted at the United Nations Environment Assembly in Dec 2017. The EU Commission also has a Waste Water Treatment Directive that assesses the effectiveness of the treatment plants for capturing microplastics. A certificate scheme under Industrial Emission Directive has been developed to reduce the marine spillage of plastic pellets.	Working with the industry to address the sources of microplastics There is a provision for the amendment of Schedule 1 of CEPA has provision to add to add new substances to the list of toxic substances by doing a risk assessment of the material.	No regulation to control microplastics other than the microbeads. The federal government a ban on microbeads w.e.f. July 2018 but it was too limited to personal care products only and does not cover the release of microplastics from other sources such as tires, paints or wastewater treatment plants. Lack of data hampers the risk assessment of the new substances under Schedule 90(1) of CEPA 1999.
LABELLING	The commission proposed to introduce labelling to differentiate between 'compostable' and 'biodegradable' plastic to ensure consumers are provided with clear information with the help of lifecycle assessment approach.	The Commission has started work to restrict alternative materials claiming to be biodegradable 'Oxo-degradable plastics' in EU. A ban has been imposed on them along with single-use plastic in March 2019. A harmonised labelling system is in place since 2018 differentiate between compostable and biodegradable plastics.	Strengthening standards for procurement, such as improving requirements for labelling or recycled content in consumer products in order to help recycle plastics in best way possible.	There is lot of problems around composting and the products cannot always be recycled. Canada has no clear labelling scheme to facilitate the sorting portion of recycling.
WATER POLLUTION	Marine Strategy Framework Directive (MSFD) under EU is a good instrument to tackle both micro and macro plastic issues mostly attributed to tourism, shipping, commercial fishing and industrial activities. There is no known method for removing microplastics from sludge under Urban Waste Water Treatment Directive (UWWTD)	The Commission is ongoing evaluation of the MSFD and UWWTD to be completed in 2019 according to the plastic strategy.	The Wastewater Systems Effluent Regulations were established under Fisheries Act to regulate the country wide municipal wastewater effluent.	The Canadian Government is investing into science based programs to understand the source of microplastics into the environment

ADDITIONAL REGULATION	*Ecolabel and Green Public Procurement* criteria has been developed as a criterion to improve recyclability of plastics. Under *Horizon 2020* EU finances research and innovation projects on better identification of contaminants and on decontamination of plastic waste. Better and more harmonized separate collection, sorting of plastic waste.	The Commission strongly supports European parliament and the council to amend waste rules to ensure better implementation of collection of plastics separately. EU has taken steps by setting requirements for member states to adopt measures to cut the consumption of plastic bags and to monitor and reduce marine litter. *Ecolabel and Green Public Procurement* running successfully to promote reusable items and packaging. *ORPLAST,* a French public procurement system is a good example to achieve great deal through economic benefits.	As a part of zero-waste strategy the federal government introduced '*Greening Government Strategy'* in 2017. Canada launched '*Oceans Plastic Charter'* at G7 meeting to endorse banning single-use plastic. The federal government in collaboration with CCME launched an action plan of the '*circular economy for plastics'.* Canada joined 'G*lobal Ghost Initiative'* to get rid of the abandoned fishing gears in the ocean.	The progress report for Greening Government strategy by Standing Committee states that although it has contributed to GHGs since 2017 launch but a lot needs to be achieved in other sectors (Standing Committee, 2019). Canada's fisheries department says that although some regional efforts are being made no national policy exist to remove gears form the Canadian waters.
WASTE MANAGEMENT	The Commission reported that the use landfill should be exceptional rather than a norm and the member states must ensure by 2035 no more than 10% of the waste is landfilled.	There has been some improvement in meeting EU requirement for waste management, however, waste treatment obligations are still not fully met. A revised directive entered into force on landfill in 2018 and must be transposed into regulation for by 2020.	Canada announced to invest $100 million to support developing countries to develop and implement sound waste management practices along with $12 million for domestic plastic innovation challenges	The waste management practices in Canada are ineffective with large amount of plastics are landfilled or incinerated and may be discharged to the environment through litter and illegal dumping.
ECONOMIC BENEFITS	Developing innovative business models, reverse logistics or designing for sustainability can do much to minimise plastic waste at source while achieving economic and social benefits. Creating new jobs with change in production and designs. Rethinking the functioning of complex value chain requiring cooperation from different stakeholders, recyclers and retailers.	Transition to circular economy increases investment, value added and jobs, and stimulates innovation. The trade within the EU has increased for paper, plastic, aluminium and copper between 2004 to 2016 helping boost the economy.	Redefining plastic waste management to gain more economic benefits such as creating more jobs by promoting innovation and redesign	Not enough focus on innovation because of less incentive provided. Low oil and gas prices markets renewables and recyclable products uncompetitive for setting markets of recyclables

CHAPTER 6: RECOMMENDATIONS

It is evident that plastic is beneficial to us in many ways and is in distinct forms, sizes and colours all around us. All the plastic produced since 1907 remains intact in the environment either in its original form (in the aquatic environment) or in its microscopic form known as microplastics. It requires about 1000 years for a plastic material to fully decompose completely from a disposal site (Leblanc, 2019). However, Canada's present strategy of handling plastic waste is unsustainable and needs to be altered. Managing the intentional or unintentional owing to human operations presents specific challenges. Despite the first few measures made in banning single-use plastic by 2021, the Canadian government is still short of achieving its objective of curbing microplastic pollution.

Many jurisdictions across Canada are investing in innovative solutions to move towards to Zero-Plastic policy. However, merely banning some plastic product or charging fees for the plastic bags will not assist the plastic waste that has been accumulated for years. We need a combined effort from the federal, provincial and territorial governments to completely get rid of the adverse effects of (micro)plastics and maintaining the water quality for the sustainable use. These efforts can only be feasible if the policies in place are strengthened. This chapter will provide some recommendations based on the comparison made through this paper that will help in the adoption of policy measures to combat microplastics pollution in the aquatic environment.

i. Improved Policies for the use and disposal of plastic waste in and around the aquatic environment

Federal Level

Canada is lagging in achieving its objective of phasing out single-use plastic and its commitment to building a sustainable future. Although the federal government has announced a ban on single-use plastic products, it still requires to be enforced at the national level. Managing problematic plastic under toxic substances list would assist in the disposal of plastic waste, thus further helping to reduce its environmental effects. The recommendations for the federal government to regulate plastic waste and microplastic pollution follow.

1. ***Add microplastic to the list of toxic substances under CEPA:*** the first and most recommended would be to add problem microplastic to the list of toxic substances under CEPA 1999. The federal government should include microplastic, microfibers, and plastic pellets in the list of toxic substances to able to monitor their release into the aquatic environment. In this regard, Prof. Buonsante stated that the government needs to move rapidly to decide what should be regulated and what should be prohibited under CEPA Schedule 1 to carry out its scientific evaluation to identify the most difficult general plastics (Personal Communication, 2019).
2. ***Regulate Nurdles:*** The federal government should take action to regulate the transport process of nurdles comparable to EU standards. As mentioned earlier in Chapter 5, a certificate scheme under "Industrial Emission Directive" has been developed to reduce the marine spillage of the plastic pellet. Similar programs should be adopted to control the unregulated accidental spillage of the plastic debris in the marine environment.
3. ***Improved Chemical Regulation:*** Canada requires enhanced chemical regulation in line with the EU REACH Directive, which has several elements such as risk evaluation,

classification and labelling to define chemicals based on their inherent characteristics (Prof. Buonsante, Personal Communication, 2019). There is currently no adequate regulation in Canada to regulate the release of chemicals into the aquatic environment and to help in further redesigning of the product. According to Prof. Buonsante, the CEPA is not well equipped for this, and the House of Commons has a report which contains a number of suggestions for reforming the CEPA that has not been accomplished but will hopefully be accomplished in the next few years.

4. ***Ghost Gear Initiative:*** To retrieve the lost fishing equipment, the federal government should promote the jurisdiction of Nova Scotia for the "Ghost Gear Initiative." With the introduction of regulations under the "Fisheries Act" and the imposition "Extended Producer Responsibility," this program can operate effectively. This program can run successfully by introducing regulations under the Fisheries Act and imposing Extended Producer Responsibility. Many such programs European nations are working effectively.
5. ***Imposing fines at national levels for littering:*** Much of the plastic around us is due to inappropriate waste disposals such as littering of plastic straws, beverage containers, or cutlery. Imposing stricter fines for littering with plastic products will encourage better recycling practices. Introduce national strategies to reduce the use of non-recyclable products.

Provincial Level

1. ***Adequate Funds:*** Provincial government should ensure that appropriate funding is provided to the waste facility for the proper functioning and further improvement of the system.
2. ***Ban Single-use Plastic:*** To support the federal government's decision, the provinces across Canada can pursue a ban on single-use plastic to help the decision of the

federal government. By charging a levy on the plastic bags and other plastic packaging across the provinces will assist in the reduction of inappropriate dumping hence the bioaccumulation of microplastics.

Municipal Level

Implementation of waste regulation: The municipal government is responsible for the full functioning of the waste disposal, reuse and recycling operations in coordination with the regional government. Proper implementation of the waste regulation will assist with the appropriate disposal of the plastic material rather than turning water surrounding us in the form of Great Lakes into the giant pool of garbage.

ii. Recycling and Ecolabelling

The recycling of plastic waste products is the most challenging task in municipal waste management. The main challenge with recycling is the sorting part, which is the expensive and time-consuming task, which involves separating things to be recycled (Prof. Buonsante, Personal Communication, 2019). There are mainly two types of recycling methods single-stream recycling and mixed stream recycling. In single-stream recycling, all the recyclable wastes go into one blue box and are subsequently gathered and sorted at the recycling plant. While in mixed stream recycling, the waste is sorted before being sent to the recycling facility. Almost all of the jurisdictions around Canada follow the single-stream recycling method. However, there is a greater possibility of contamination in single-stream recycling due to waste mixing contaminates recyclable products that pose a health danger and decreases their recycling capacity.

Furthermore, the lack of information about the chemical composition of the products hampers further recycling of plastic waste products. Ultimately the product finds their way to the landfills where it leeches chemicals into the environment for years. Here are some of the recommendations for the effective recycling of plastic products.

Federal Level

1. ***Improved laws and regulations:*** The federal government should coordinate with municipal governments to have improved laws and regulations for curbside waste collection. Instructions should be provided to separate the trash into recyclable and non-recyclable products to make recycling easier***.***
2. ***Discourage landfilling/incineration:*** To decrease the burden of recycling and landfilling, the government should encourage public investment in sustainable products. Furthermore, incineration is also not an option to waste dumps. To prevent unnecessary loss of valuable energy resource through landfilling and incineration, the European Commission has established different waste-to-energy processes (European Commission, 2019). Canada should follow suit to recapture the value of the product rather than allowing them to disappear into the landfilling or incineration after a single-use.
3. ***Eco-labelling*** is an innovative step towards sustainable development to help the consumer know whether the product is eco-friendly or recyclable. Eco-Labelling has been successfully implemented in West Germany as "Blue Angel" program in 1978 (Blue Angel, The German Ecolabel, 2019). Many countries such as the United States, Australia, Japan, Austria and Italy have since then adopted this method and running successfully. In Canada also, we need such regulations to support the recycling system and prevent the toxic chemical leaching from plastic waste disposal.

Provincial Level

1. ***Integrated recycling system:*** An integrated system is required to promote the effective recycling of plastic goods involving support from the federal, provincial and territorial governments. Use of landfilling or Incineration should be discouraged.
2. ***Green Procurement:*** Green Procurement should be encouraged at public places.
3. ***Recycling:*** Each province should contribute to the increased recycling rate of the country by setting up individual recycling rates for their provinces.

Municipal Level

1. ***Separate collection:*** There is a high risk of contamination of recyclable products that reduces the number of plastics that can be reused. Improved strategies are needed for separate collection of plastic waste to be recycled under the curbside blue box recycling program. This will help in minimizing the cost of sorting the waste at the waste facility and also increased the recyclability of the product for future reuse.
2. ***Labelling at a regional level:*** According to Prof. Buonsante, there is no municipality in Ontario that accepts coffee pods as compostable. According to him, there are numerous issues around the compostable products such as straws, coffee pods, which require certain conditions such as an optimal 60-120 Celsius temperature or a 5-10 years' limit or longer to biodegrade. Hence having a proper labelling system similar to the one adopted in the EU such as "ORPLAST" or "BLUE ANGEL" in Germany will contribute to identifying the compostable products and in further recyclability of the product (European Commission, 2019).

iii. Circular Economy

For years, Canada has been adapted to the linear approach of product usage where Take, Make and Dispose of are the three essential steps. The linear economy presently being used by Canada for waste disposal leads to accelerated depletion of our natural resources as well as disastrous changes to our surroundings. The circular economy, on the other hand, would help to achieve the targets for global initiatives such as sustainable development goals and move towards a more sustainable future. The circular economy is a sustainable solution to the challenges faced by the federal government for its plastic waste management. It has yet to be implemented nationally in Canada; however, this program has successfully been implemented in Europe since 2015. Following are the recommendations for the successful implementation of the circular economy in Canada.

Federal Level

1. The ***EPR*** should be implemented as national EPR program to help redesign and regenerate a completely new product for the consumer. The producers should be encouraged to build a reverse supply-chain for their products under EPR.
2. ***Federal Funding:*** The federal government should provide funding for the research and innovative solutions aimed at better designing of the product with reduced impact on the environment.
3. ***Green Procurement:*** The federal government should encourage "*Green Procurement*" under a circular economy in the government offices that promote the reduction of waste.
4. ***Circular Economy:*** The federal government should coordinate with the industry, stakeholders and other municipal governments for the successful implementation of the circular economy nationally.

Municipal/Provincial Level

Municipal and Provincial government should work collaboratively to develop a market for the recycled product to increase demand to support better product design. The better product design will also help with the increased recyclability of the product. The use of reusable bags made from renewable material should be encouraged as they do not take longer to degrade into the environment. There are many biodegradable plastic bags options available in the market.

iv. Education and Public Awareness

Plastic products are favourite amongst both consumers and manufacturers because of their durability, low price and long life. Hence, we tend to ignore the harmful impact on the environment to gain economic benefits from them. People around us understand that plastic is problematic, but they have become so accustomed to these plastic products because it is super cheap right now (Prof. Buonsante, Personal Communication, 2019). We have been living in this culture for nearly 50 years where we buy products wrapped in plastic, bring that home, unwrap it and throw away the plastic (Prof. Buonsante, Personal Communication, 2019). Listed below are some of the recommendations for public awareness at the federal as well as municipal level.

Federal Level

1. ***Increased public participation:*** Increased participation of the public through the introduction of domestic voluntary programs such as shoreline cleanup projects, green procurement, lost gear procurement will assist in reducing the quantity of waste already produced from inappropriate disposal procedures.

2. ***Accessible centralized system:*** Creating an easily accessible centralized information system for product information will assist in gaining more insight into the program such reusability and disposal of the product.

Provincial Level

Educational programs concentrating on the impacts of the microplastics on land as well as aquatic ecosystems should be introduced. Recycling strategies should be introduced as a part of the curriculum in schools. Educate children at an early age about the reduction of waste with a specific focus on single-use plastic. Education plays a vital role in the successful implementation of a program. According to Prof. Buonsante education is very useful to accept a change in the system.

Municipal Level

1. ***Community-based program:*** Municipalities should conduct various community-based programs to increase awareness about plastic waste management and motivate the local community for safe plastic waste disposal.
2. ***Shoreline Cleanup:*** Municipalities should have more shoreline cleanup program and beach cleanup to promote the public plastic awareness and keeping it away from seas, rivers and lakes away.

CONCLUSION

Water is an essential natural resource, and our world is facing a water crisis resulting from inappropriate usage. Pollution is restricted not only to soil and oceans but also to the

decreasing aquatic animal population. It has been noted that non-point sources are the most difficult to regulate through regulation as in most instances the cause is unknown, but managing point sources is equally essential as this is inadequately executed at the federal level. The accumulation of plastic litter in freshwater ecosystems is one of the most visible but least studied areas of the environment (Wagner et al. 2014; Brennholt et al. 2017a). Understanding the composition of plastics found in the marine environment with the help of research will help develop policies that need to be implemented across Canada and internationally (S. Pettipas et al., 2016). Although enforcement of macroplastic disposal management is growing, the knowledge or law around microplastics is lacking (S. Pettipas et al., 2016). Plastic can be of many uses, including future technological advances in the medical field (Thompson et al. 2009). However, the current usage and the methods for plastics disposal are taking a toll on the environment.

Canada has already taken up first steps towards banning microbeads in July 2018, but there is still a lot to be done in the field of microplastics. Although the prohibition is the most crucial step in effective monitoring of microplastics discharge and effects in the aquatic setting, the transition to a microplastic setting in Canada is regarded as slow in relation to the EU. One way is to review the microbeads ban, which is very limited. However, if we look at the EU Plastic Directive for the microplastic ban, it includes microplastics found in many more products such as fertilizers and detergents (Prof. Buonsante, Personal Communication, 2019) which seems to be broader. Hence there is an opportunity to broaden a bit the scope to ban microbeads in Canada and to address this issue with a combination of standardization and a possible ban on single-use plastic (Prof. Buonsante, Personal Communication, 2019). The federal government lacks a set agenda to manage microplastic pollution. The ban can be useful for the management of macroplastic from which the fragments of microplastics are

formed. However, the regulations for microfibers, fishing nets and plastic pellets are yet to be released.

Sustainable Development is a kind of concept that has received increased acceptance throughout the world in recent years and has become a base of many government policies. The most encompassing an overarching framework of plastic waste management is probably Agenda 2030 for Sustainable Development, and both its goals SDG 6 (clean water and sanitation) and SDG 14 (ocean conservation) is partially concerned with the issue of plastics (Simon and Schulte, 2017). Waste management should utilize techniques to restructure the entire economy by putting less burden on natural resources and protecting the environment for the future generation.

According to Prof. Buonsante, to make the circular economy as a successful idea, it needs to integrate reduce, reuse, and refurbish into the scheme not just focusing on recycling the product because even the best quality plastic like PET lose its volume and cannot be recovered for an extended period. More focus should be given to reusability and the durability of the product with the help of innovative designs such as plastics in electronics which is not single-use, but their longevity is quite limited (Prof. Buonsante, Personal Communication, 2019). Plastic can be of many uses, including future technological advances in the medical field (Thompson et al. 2009) it's time for Canada to follow the footsteps of BC in terms of 5Rs (Reduce, Reuse, Recycle, Recover, and Residual management) hierarchy instead of their current Prevent, Recover and Recycle hierarchy. This current usage and the methods for plastics disposal are taking a toll on the environment.

We need enhanced waste management strategies to control plastic pollution in Canada. The effective waste management policies are required to address the problem of (micro)plastics litter both on land and in water. It contributes to the attainment of sustainable development goals set by the United Nations Environment Program. We need radical action from the federal government to tackle the issue of microplastics. Short-term measures such as improving waste management practices recycling or introducing tax will be suitable for the plastic that has not been produced. However, we must rethink from a long-term view to monitor both manufacturing and consumption of plastic and the interventions taken to clean the plastic in the surroundings already.

Although enforcement of macroplastic disposal management is growing, there is a lack of understanding or legislation on microplastics (S. Pettipas et al. 2016). The effective waste management policies are required to solve the problem of (micro)plastic litter both on land and in water. The World Wildlife Fund (WWF) along with the Vancouver Aquarium holds an annual event to promote awareness and understanding about the ocean litter and encourage Canadian for shoreline cleanup programs (S. Pettipas et al., 2016). Many big companies such as Nestle' and Coca Cola have pledged to support single-use plastic ban under OCEANS PLASTIC CHARTER. Canada is still in a process to introduce a highly effective policy instrument to deal with many environmental problems in the country, and microplastic management is one of them. We have extensive information accessible through research studies on the harmful impacts of plastic on both terrestrial and water ecosystems, but the public is still less well informed about this. Many people feel that taking care of the environment and its management is not under their control. We have sustainable alternatives in the market, but the absence of understanding and consciousness acts as the most

important obstacle in moving towards them and protecting the environment from the effects of unsustainable operations.

Canada is doing good, but it's not there yet. Canada is taking baby steps as compared to the EU Commission, which is making leaps in mitigating the impacts of microplastics in its aquatic ecosystem. We do have practical alternatives available in the market that we need to pursue. There is a need for an integrated effort from federal, municipal and provincial governments. Bringing a ban on single-use plastics may assist in mitigating secondary microplastics, but we also need other measures to support the ban as adopted by the EU Commission.

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Appendices

APPENDIX A: SAMPLE INTERVIEW

My research topic is "Review of the federal policy to mitigate the impact of microplastics and I am investigating "the policy models available mitigate the impact of microplastics both marine and freshwater ecosystems" also "What are the future plans of the federal government to keep microplastics out of Canadian Waters?"

1. What is your title and position in this organization? What is your current project that you are working on?

2. Countries around the world have started to acknowledge significant contribution of plastic products in deteriorating the quality of water. More than the plastic the scientist and environmentalist are more concerned about the microplastics in the aquatic environment. With the recent federal government announcement to ban single-use plastic Would a ban on some plastic products be enough to solve the problem of microplastics?

3. The single-use plastic ban would control the formation of fragments of macroplastics into microplastics. What about the primary microplastics that enter into the aquatic environment in their original shape and form such as Nurdles or fibres from synthetic fabric items or the ones that are is already there?
   (Probe) In your opinion are there any policies/regulations available to control the accidental spillage of Nurdles or for the abandoned fishing gears into the aquatic ecosystem?

4. In your opinion are we moving towards CE as we see in EU plastics directive where they stress upon CE and have also included innovation and design into the program?
   (Probe) How effective is the CE as a tool to curb microplastic pollution?

5. Apart from recycling what else do you think should be made a part of the CE model in Canada to make it more successful in managing microplastics pollution?

6. The EU last year released its single-use plastic strategy that focusses on 10 items that are mostly found on the beaches the data for which is being collected in context with the implementation of the marine strategy framework directive. Are there any similar criteria that are going to be followed by the federal government to identify the products to target for plastic waste management? If yes, what are those?

7. The federal government in its recent announcement has said that the producers will be held responsible for their manufactured products. Having no access to big technology or lack of funding the small business might have difficulty in switching to circular economy. what is the role of federal government here to help small businesses for easy transition?

8. Awareness about environmental issues is the most crucial step both for the producers and the consumers. How do we overcome the restrictions from industries, especially the small businesses that require funding to support a ban or shift from a linear economy to CE? How can we bring a change in our society? Some people are hard to convince and unwilling to change their behavior.
   (Probe) Would legislation be enough to bring an impactful change in society? Or do we need a combination of education and legislation to convince the consumers?

9. The federal government last year banned microbeads under CEPA. In your opinion, what role does CEPA play in controlling the release of microplastics on the aquatic environment?
   (Probe) What gaps did you find in the present government's policies in managing the plastic waste in the aquatic environment especially in the case of microplastics?

10. The plastic product is a complex structure of polymers that includes different types of chemicals. Under EU circular economy model REACH is being used as a tool to register their problematic chemicals used in the manufacturing of plastic material hence helping in the recycling of the product. Does Canada have any such system available to be enforced under the circular economy model for plastic management?
    (Probe) In your opinion does Canada has any eco-labelling system to identify harmful chemicals?

11. We often talk about plastic that are decomposable, would you like to comment on that?

12. Would you like to add something in your final comments and recommendations to mitigate the impact of microplastics in the aquatic environment?

APPENDIX B: INFORMED CONSENT FORM

Study Name

Review of Federal policy framework to mitigate the impact of microplastics

Researcher Information

- ***Name: Shivani Chhabra***
- ***Email: shivani_chawla@outlook.com***
- ***Phone: (647)262-9709***
- ***Student Status: MES, FES, York University***

Purpose of the Research

The main objective of the study is to understand the movement of land-based plastic debris to the aquatic environment and their impact on the aquatic ecosystem. The study also aims to review the current federal government's policy framework to mitigate the effects of microplastics on the aquatic environment. The results from the study will be shared with the researchers and agencies with the help of websites, journals and books, who are working on similar projects.

Your Role in the Research

You will be asked to volunteer for an interview that should last for approximately an hour. During the interview, you will be asked about your past experiences and challenges you face. You will also be asked about opinion about the current changes to Canadian Environmental Protection Act, (CEPA). Any recommendation you have to improve the present federal policy framework would be welcomed. The interview will be audio/video recorded.

Risk and Discomfort

I do not foresee any major risk or discomfort with your participation in the interview process. You may skip any question that you do not wish to answer at any point of time during the interview process. You may end your participation in the study process at any point without any adverse consequences.

Benefits of the Research

There may be no personal benefit from your participation in the research process but the information received will make a big difference for the betterment of the public. Whenever applicable the alternatives of the study will be disclosed to the participants.

Incentives

There will be no incentives provided for your participation in the study.

Ending your Participation

Your participation in the study is completely voluntary. You have all rights to withdraw from the study at any time without any questions being asked from you. Your refusal will not affect your relationship with us. If you withdraw from the study during the study all the data collected will be returned to you or destroyed.

Confidentiality

By agreeing to participate in the study, you have a choice to keep your data confidential or making your notes public. Confidentiality will be provided to the fullest extent possible by law. If you choose to keep your interview confidential, your data will be protected in the hard drive. You will have the opportunity to review your data before it is being posted to any website or journal. Should you wish to withdraw at any point in time, all data generated as a consequence of your participation will be destroyed.

Once the interview is transcribed the audio will be destroyed immediately and the transcripts will be kept in the password protected folders. They will be deleted within two years of the research study.

Questions

If you have any questions about the research or about your rights as a participant in the study, please feel free to contact

- ***Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, Kaneff Tower, York University (telephone 416-736-5914 or email ore@yorku.ca) and***
- ***Supervisor: Mark S. Winfield (email marksw@yorku.ca)***

This research has received ethics review and approval by the Ethics Review Committee, which is delegated authority to review research ethics protocols by the Human Participants Review Sub-Committee, York University's Ethics Review Board, and conforms to the standards of the Canadian Tri Council Research Ethics guidelines.

Rights and Signature

By signing below, you agree that you have read the information or the information has been explained to you and you have understood the process of interview. By signing this document below, you agree to participate in this research study.

_____ _____
PARTICIPANT SIGNATURE DATE

_____ _____
INVESTIGATOR SIGNATURE DATE

Confidentiality

By signing below, you give your permission to be identified by name in any publications or presentations for the research.

PRINT NAME

_____ _____
PARTICIPANT SIGNATURE DATE

Audio/Video Recording Consent

I consent to do the audio/video recording of my interview

_____ _____
PARTICIPANT SIGNATURE DATE